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INSTRUCTION MANUAL

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131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352 U.S.A.
(212) 461-7000 • TWX #710-582-2631

KEPCO
NTC
PROGRAMMING INTERFACE

Model NTC 2000

Serial No. A75837

INSTRUCTION MANUAL

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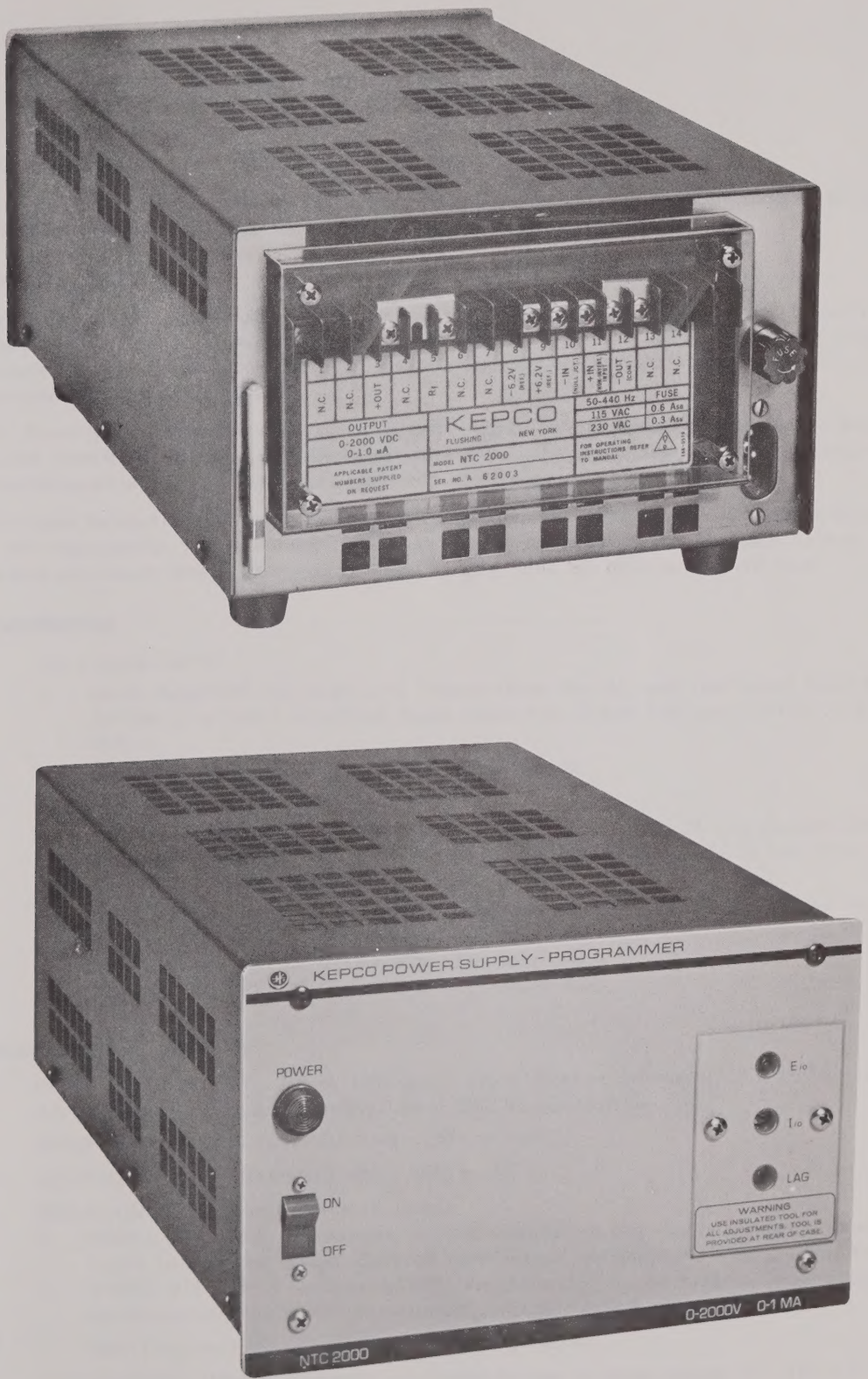

FIG. 1-1 NTC POWER SUPPLY, TYPICAL FRONT AND REAR VIEWS.

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SECTION I – INTRODUCTION

1-1 SCOPE OF MANUAL

1-2 This instruction manual contains information for the installation, operation and maintenance of the Kepco NTC Power Supply-Programmers.

1-3 GENERAL DESCRIPTION

1-4 Kepco NTC Power Supply-Programmers are interface devices, designed to be used in conjunction with power supplies whose "common" terminal is the positive output. NTC Power Supply-Programmers provide a convenient way to reverse the polarity of the programming signal, making the power supply's negative output "common" to the signal source.

1-5 NTC Power Supply-Programmers are completely self-contained voltage supplies with built-in d-c reference sources, fixed feedback resistor, compensated amplifier and shunt regulator stage. All necessary programming terminations are provided on front panel binding posts as well as on a rear barrier-strip.

1-6 NTC Power Supply-Programmers are constructed in a "quarter-rack" or "half-rack" configuration, depending on the model number. The main chassis and the wrap-around cover are from cold-rolled steel; the front panel material is aluminum. Refer to "Mechanical Outline Drawing" (FIG. 1-2) for dimensions and finish.

1-7 ACCESSORIES

a) HALF-RACK UNITS:
   1) RACK ADAPTER (for single unit): Kepco Model RA–24, with filler panel, Kepco Model RFP 24–2, or RACK ADAPTER Kepco Model RA–32 with filler panel RFP–1, RFP–2 or RFP–3.
   2) RACK ADAPTER (for two units): Kepco Model RA–24.

b) QUARTER-RACK UNITS:
   1) RACK ADAPTER (FOR FOUR UNITS): KEPCO MODEL RA–24. Fits standard EIA rack dimensions, or RACK ADAPTER (for two units): Kepco Model RA–32 with filler panels RFP–1, RFP–2 or RFP–3.
   2) FILLER PANELS to cover empty slots if adapter is used for less than its capacity (for RA–24):
      KEPCO MODEL RFP 24–1, to cover one (1) empty slot.
      KEPCO MODEL RFP 24–2, to cover two (2) empty slots.
      KEPCO MODEL RFP 24–3, to cover three (3) empty slots.

1-8 SPECIFICATIONS, GENERAL

a) INPUT REQUIREMENTS: 105 to 125V a-c or 210 or 250V a-c (selectable), 50 to 65 Hz, single phase. A-C input source current approximately 0.3A at 125V a-c, power factor 0.9.

b) AMBIENT OPERATING TEMPERATURE: –20°C to +65°C.

c) AMBIENT STORAGE TEMPERATURE: –40°C to +85°C.

d) ISOLATION: Output is isolated from the chassis:
   1) MODEL NTC–2000: A maximum of 1000 volts (d-c or p-p) may be connected between either output terminal and ground. Common mode current, output/ground = 30 μA rms, 300 μA p-p.
   2) MODEL NTC–200: A maximum of 500 volts (d-c or p-p) may be connected between either output terminal and ground. Common mode current, output/ground = 5 μA rms, 50 μA p-p.

   Note: Common mode current measured at 115V a-c, 60 Hz.

e) PROGRAMMING: May be controlled by external voltage or current signals. The NTC is a 3-terminal device, producing a positive output for a negative input with reference to the common (negative).

f) MAXIMUM CAPACITIVE LOADING: 0.001 microfarads. Excess capacitance slows the response time and may cause instability or high-frequency oscillations at the output.

g) CURRENT LIMIT: Output current is limited to approximately 110% of the rated value when operating into a short circuit. Recovery is automatic when overload is removed.

h) INPUT OFFSETS: The fixed (initial) part of the input offset voltage (E_{io}) and the input offset current (I_{io}) can be nulled by means of the built-in panel controls. The variable parts of the input offsets (ΔE_{io}, ΔI_{io}) are specified in TABLE 1-2. These offset errors (and any input or bias source used) contribute to the output voltage change (ΔE_o). Since the total output voltage error is also dependent on the input and feedback resistors used, ΔE_o is calculated for each application using the error equation:

$$\Delta E_o = \pm\Delta E_i \ (R_f/R_i) \ \pm\Delta E_{io} \ (1 + R_f/R_i) \ \pm\Delta I_{io} R_f,$$

where R_f and R_i are the feedback resistor and the input resistor respectively.

1-9 SPECIFICATIONS, PERFORMANCE

a) OUTPUT: (See TABLE 1-1.)

MODEL	d-c OUTPUT RANGE VOLTS	mA	OUTPUT IMPEDANCE dc OHMS + SERIES L	SLEWING RATE
NTC–200	0–200	0–10	3.4Ω + 10 μH	1V/μsec.
NTC–2000	0–2000	0–1	334Ω + 100 μH	3V/μsec.

TABLE 1-1 OUTPUT SPECIFICATIONS

b) INPUT OFFSET SPECIFICATIONS: (See TABLE 1-2.)

INFLUENCE QUANTITY		VOLTAGE AMPLIFIER OFFSETS ΔE_{io}	ΔI_{io}	REFERENCE ± 6.2V
SOURCE: 105–125/210–250V a-c		<100 μV	<10 nA	0.0005%
LOAD: No load – full load		<1 mV	<10 nA	———
TIME: 8-hours [drift]		<20 μV	<5 nA	0.005%
TEMPERATURE: Per °C		<20 μV	<5 nA	0.005%
UNPROGRAMMED OUTPUT DEVIATION(1) Ripple and noise	rms	<0.01% or 5 mV(3)		———
	p-p(2)	<0.05% or 50 mV(3)		———

(1) One terminal grounded, or connected so that common mode current does not flow through the load.
(2) 20 Hz to 10 MHz. (3) Whichever is greater.

TABLE 1-2 OFFSET AND REFERENCE SPECIFICATIONS.

c) OPEN LOOP D-C GAIN: $>0.5 \times 10^6$ volts per volt.

d) OUTPUT SLEWING RATE: Refer to TABLE 1-1. The maximum SLEWING RATE is measured (in volts per microseconds) on the exponential output response to a square wave input signal. It is the fastest rate of change which can be obtained by overdriving or "forcing."

e) SINUSOIDAL FREQUENCY RESPONSE: Calculate by means of the equation:

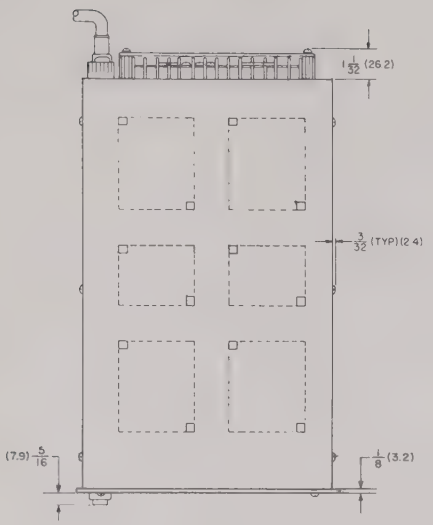
$$f_{max.} = \frac{\text{SLEWING RATE}}{\pi E_{pp}}$$

where E_{pp} is the peak-to-peak magnitude of the programmed output voltage.

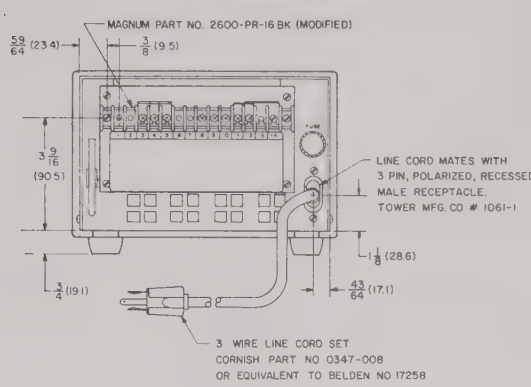
f) PROGRAMMING TIME CONSTANT: Given by the RC product of the built-in feedback resistances/capacitances.
Model NTC–200: R_f = 200K, C_f = 350 μμF.
Model NTC–2000: R_f = 2 M, C_f = 100 μμF.

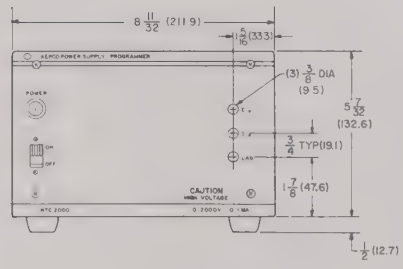
1-10 SPECIFICATIONS, PHYSICAL

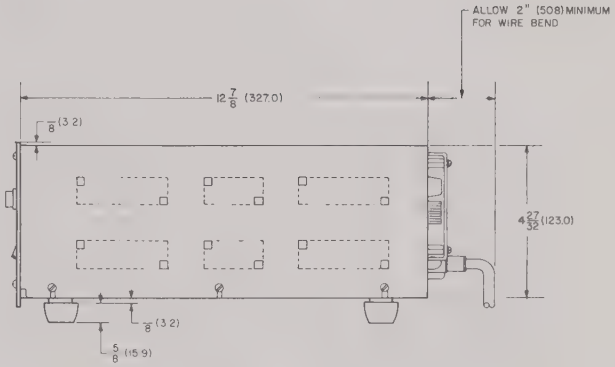
a) Refer to "Mechanical Outline Drawing" (FIG. 1-2).



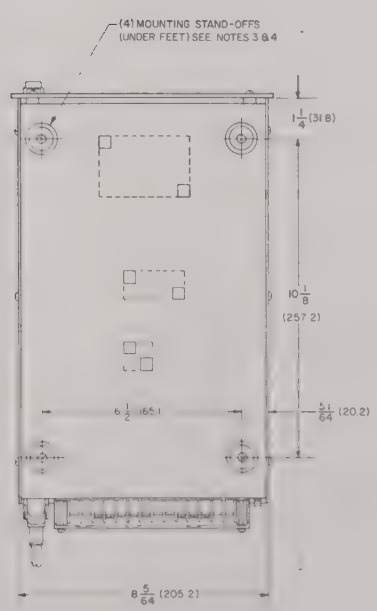
REAR OUTPUT & PROGRAMMING TERMINALS


MAGNUM PART NO. 2600-PR-16 BK (MODIFIED)
59/64 (23.4)
3/8 (9.5)
3 9/16 (90.5)
LINE CORD MATES WITH 3 PIN, POLARIZED, RECESSED MALE RECEPTACLE. TOWER MFG. CO # 1061-1
1 1/8 (28.6)
3/4 (19.1)
43/64 (17.1)
3 WIRE LINE CORD SET CORNISH PART NO 0347-008 OR EQUIVALENT TO BELDEN NO 17258





REAR OUTPUT AND PROGRAMMING TERMINALS	FUNCTIONS
1	NO CONNECTION
2	NO CONNECTION
3	(+) OUTPUT
4	NO CONNECTION
5	R_S
6	NO CONNECTION
7	NO CONNECTION
8	(-) 6.2V (REFERENCE)
9	(+) 6.2V (REFERENCE)
10	(-) INPUT (NULL JUNCTION)
11	(+) INPUT (NON-INVERTING INPUT)
12	(-) OUTPUT (COMMON)
13	NO CONNECTION
14	GROUND (CHASSIS)



NOTES

1. MATERIAL: COVER, 20 GAUGE COLD ROLLED STEEL
   FINISH - HARTIN'S #6389 CHARCOAL GRAY VINYL TEXTURE FINISH
   FRONT PANEL, 1/8 THICK ALUMINUM
   FINISH - LIGHT GREY PER FEDERAL STANDARD 595
   COLOR NO. 26440
2. FUSE DATA: 115 VOLT AC, 0.6A SLO BLO 230 VOLT AC, 0.3A SLO BLO
3. REMOVE (4) FEET FOR RACK MOUNTING
4. USE (4) 8-18 X 5/8 SELF-THREADING SCREWS (FOR 1/8 THICK MOUNTING SURFACE)
5. DIMENSIONS WITHIN PARENTHESES ARE IN MILLIMETERS
6. REFER TO KEPCO CATALOG FOR DETAILED SPECIFICATIONS
7. TOLERANCES:
   A) BETWEEN MOUNTING HOLES ±1/64 (±0.4)
   B) ALL FRONT PANEL DIMENSIONS TO MIL STD 189
   C) ALL OTHER DIMENSIONS ±1/32 (±0.8), EXCEPT AS NOTED

FIG. 1-2 MECHANICAL OUTLINE DRAWING.

SECTION II – INSTALLATION

2-1 UNPACKING AND INSPECTION

2-2 This instrument has been thoroughly inspected and tested prior to packing and is ready for operation. After careful unpacking, inspect for shipping damage before attempting to operate. Perform the preliminary operational check as outlined in paragraph 2-11 below. If any indication of damage is found, file an immediate claim with the responsible transport service.

2-3 TERMINATIONS

a) FRONT PANEL: Refer to FIG. 2-2 and TABLE 2-2.

b) REAR: Refer to FIG. 2-3 and TABLE 2-3.

c) INTERNAL ADJUSTMENTS (Refer to FIG. 2-1 and TABLE 2-1.)

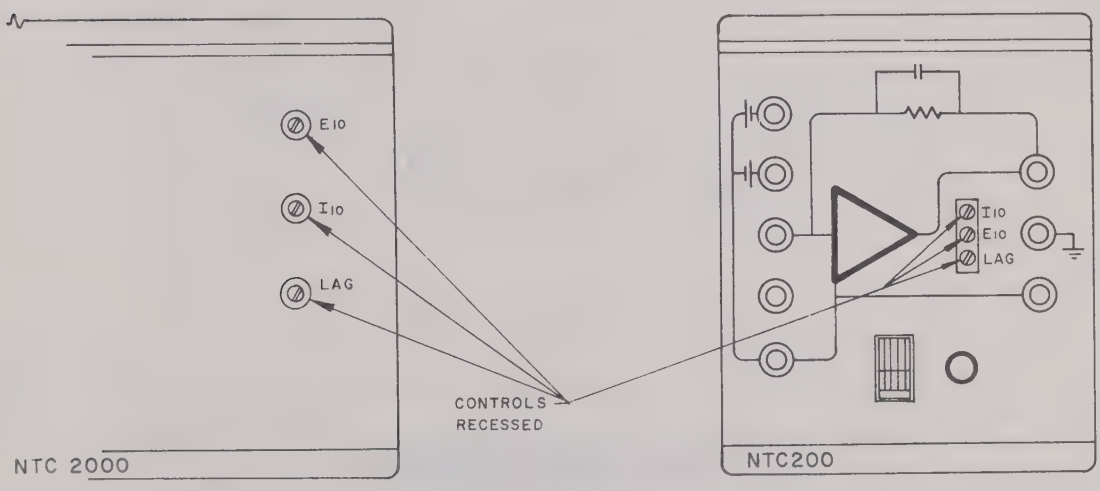


FIG. 2-1 LOCATION OF INTERNAL CONTROLS.

REFERENCE DESIGNATION	CONTROL	PURPOSE	ADJUSTMENT PROCEDURE
R12	E_{io} Null	Offset Voltage Zero Adjustment	Par. 3-4
R15	I_{io} Null	Offset Current Zero Adjustment	Par. 3-4
R9	Lag	A-C Stability Adjustment	Par. 3-14

TABLE 2-1 INTERNAL CONTROLS.

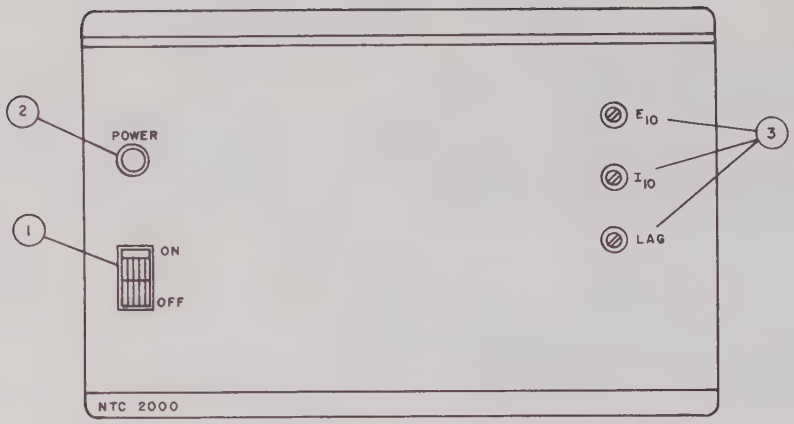


FIG. 2-2 CONTROLS AND TERMINATIONS, FRONT.

NO.	CONTROL OR TERMINATION	FUNCTION
1	A-C POWER SWITCH	TURNS POWER "ON" OR "OFF"
2	A-C LINE INDICATOR	INDICATES LINE POWER "ON" WHEN ENERGIZED
3	RECESSED ADJUSTMENTS	OFFSET ZEROING, LAG ADJUSTMENTS

TABLE 2-2 CONTROLS AND TERMINATIONS, FRONT.

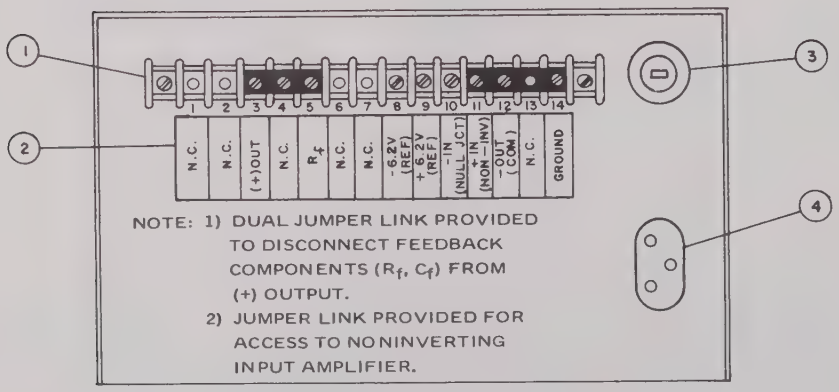


FIG. 2-3 TERMINATIONS, REAR.

NO.	TERMINATION	FUNCTION
1	REAR BARRIER-STRIP	REAR TERMINALS, SEE FIG. 2-3 FOR ALL FUNCTIONS PROVIDED
2	DECAL	TERMINAL DETAILS FOR REAR BARRIER-STRIP
3	FUSE	PROTECTS PRIMARY OF MAIN TRANSFORMER
4	LINE INPUT	SOCKET FOR (SUPPLIED) SAFETY LINE CORD

TABLE 2-3 TERMINATIONS, REAR.

2-4 A-C POWER REQUIREMENTS

2-5 The Kepco NTC Power Supply-Programmer is normally delivered for operation on a single phase, 105 to 125V a-c line, 50 to 65 Hz. For operation on 210 to 250V lines, the jumper connections on the transformer (T202) must be changed as shown in FIG. 2-4.

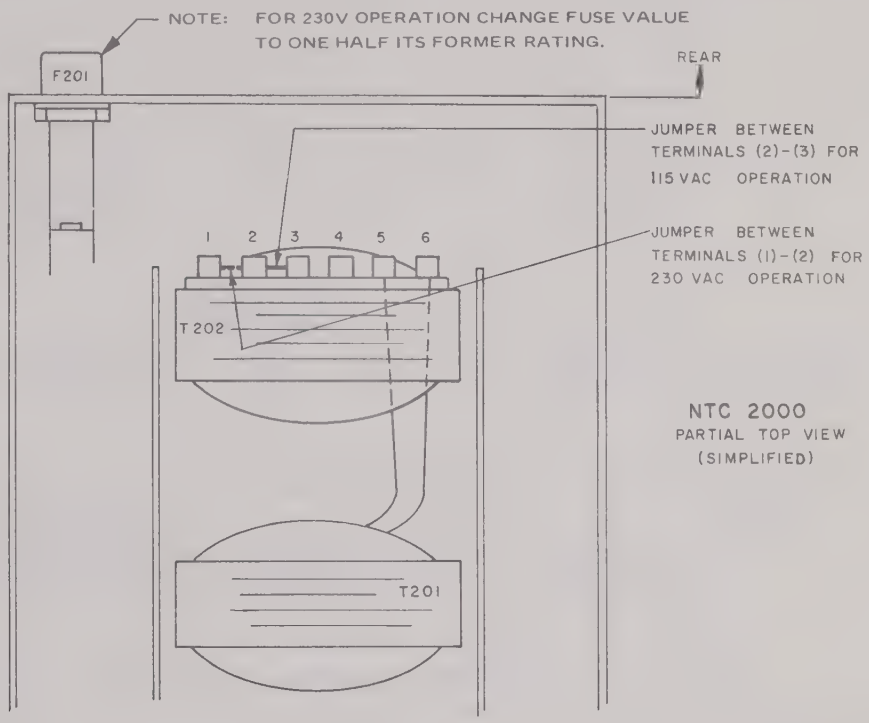

NOTE: FOR 230V OPERATION CHANGE FUSE VALUE TO ONE HALF ITS FORMER RATING.
F201
REAR
JUMPER BETWEEN TERMINALS (2)-(3) FOR 115 VAC OPERATION
JUMPER BETWEEN TERMINALS (1)-(2) FOR 230 VAC OPERATION
1 2 3 4 5 6
T202
T201
NTC 2000
PARTIAL TOP VIEW
(SIMPLIFIED)

FIG. 2-4 TRANSFORMER CONNECTIONS FOR 115V A-C AND 230V A-C OPERATION.

2-6 GROUNDING

WARNING

2-7 THE HIGH VOLTAGES PRESENT IN THIS EQUIPMENT MAKE IT IMPERATIVE THAT THE CASE IS KEPT AT GROUND POTENTIAL AT ALL TIMES. If the 3-wire line cord with 3-prong safety plug (supplied with this equipment) is used in combination with a properly grounded outlet, this is taken care of automatically. If an adapter for an ungrounded outlet is used, however, the case must be grounded separately. **GROUNDING TERMINALS HAVE BEEN PROVIDED ON THE NTC REAR BARRIER STRIP, SEE FIG. 2-3.**

2-8 It is good practice to ground one side of the output at all times. The NTC has been specifically designed such that the NEGATIVE (COMMON) terminal can be operated at ground potential. Where circuit requirements do not permit grounding of either side of the output, additional precautions against dangerous electrical shocks must be taken. Equipment used in conjunction with high voltage operational power supplies must be able to withstand the operating voltage of the latter. Properly insulated wires are essential.

2-9 COOLING

2-10 The Kepco NTC Power Supply-Programmer is designed for adequate convection cooling through the wrap-around, perforated case under specified operating conditions. Sufficient space around the unit must be allowed for free air circulation. If the instrument must be mounted into confined spaces, forced-air cooling may be necessary to keep the surrounding air within the specified ambient temperature limits.

2-11 OPERATIONAL CHECK

2-12 After unpacking the instrument and before permanent installation, an operational check should be performed as described below.

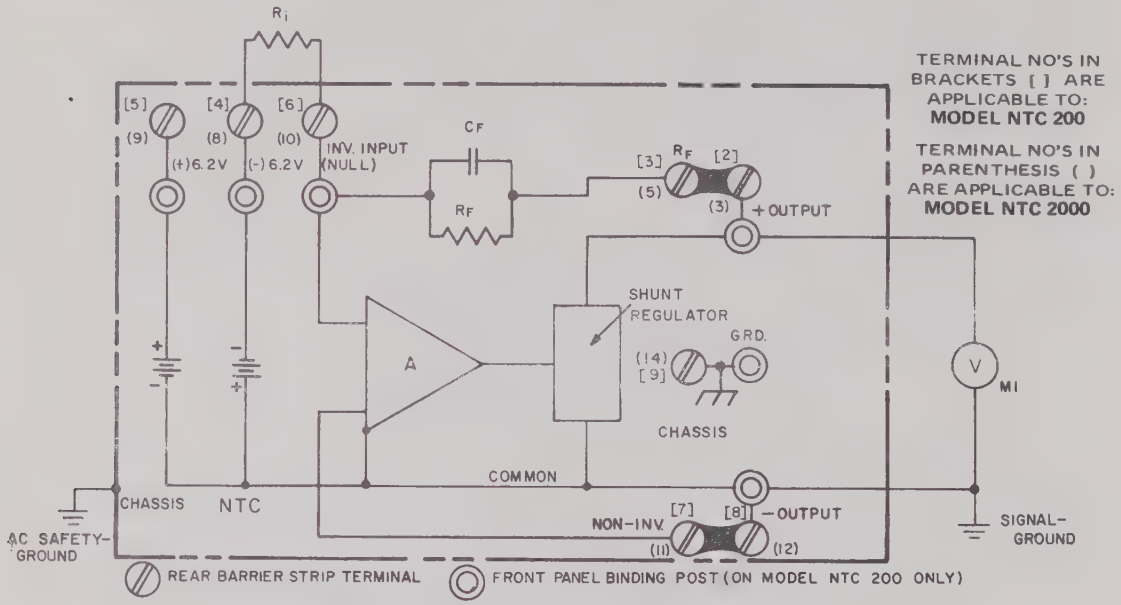


FIG. 2-5 PRELIMINARY CHECK SETUP.

a) The NTC is operated as a unipolar operational power amplifier using the internal reference source and a suitable input resistor R_i. Selection of R_i may proceed according to the operational equation:

$$-E_o = E_r \frac{R_f}{R_i}$$

EXAMPLE FOR NTC–2000: Since E_r = 6.2V and R_f = 2 megohms are given,* we may select the test voltage on the basis of the meter (M1) available. Assuming E_o = 1000V, we can calculate the input resistor required by:

$$R_i = \frac{6.2V\ (2 \times 10^6\ \Omega)}{1000V} = 12.4 \times 10^3 \text{ ohms.}$$

A 12.4 K ohm resistor will therefore produce approximately 1000 volts at the output. Connect components as shown and turn unit "on." Observe output voltage at M1. This concludes the preliminary test.

b) EXAMPLE FOR NTC–200: Since E_r = 6.2V and R_f = 200 K ohms are given,* for a test voltage of 200 volts, the input resistor (R_i) must be:

$$R_i = \frac{6.2V\ (2 \times 10^5\ \Omega)}{200V} = 6.2 \times 10^3 \text{ ohms.}$$

A 6.2 K ohm resistor for R_i (metal film or w.w. 1/2W) will produce the selected output voltage of 200 volts. Connect components as shown in FIG. 2-5 and turn NTC "on". Observe output on the voltmeter (M1). This concludes the preliminary test.

*The built-in feedback resistor (R_f) and the internal reference source (E_r = 6.2V nominal) are used for this test.

SECTION III – OPERATION

3-1 GENERAL

3-2 a) MODEL NTC–2000: This model is of hybrid design, using a vacuum tube in a shunt regulator configuration. A built-in thermal time delay of approximately 30 seconds is activated by turning the unit "on." Output is available after the delay.

b) MODEL NTC–200: This model has a power transistor in the shunt regulator stage. Ouput is therefore immediately available.

c) BOTH MODELS: Before critical adjustments or applications, a warm-up period of about 30 minutes should be allowed to insure thermal equilibrium of all critical components.

3-3 EXTERNAL CONNECTIONS

WARNING

THIS INSTRUMENT IS CAPABLE OF PRODUCING LETHAL VOLTAGES. ALL CONNECTIONS TO AND FROM THE UNIT MUST BE MADE WITH THE A-C INPUT POWER CORD REMOVED FROM THE UNIT.

a) Input and output connections may be made either at the front panel or at the rear barrier-strip (TB201) where all front panel terminations are duplicated. (Refer to FIG. 3-1.) Extra terminals are provided at the rear barrier-strip for disconnecting the feedback components (R_f, C_f) from the (+) output and to make the noninverting amplifier input available for special applications.

NOTE: Front panel binding posts provided on Model NTC–200 only.

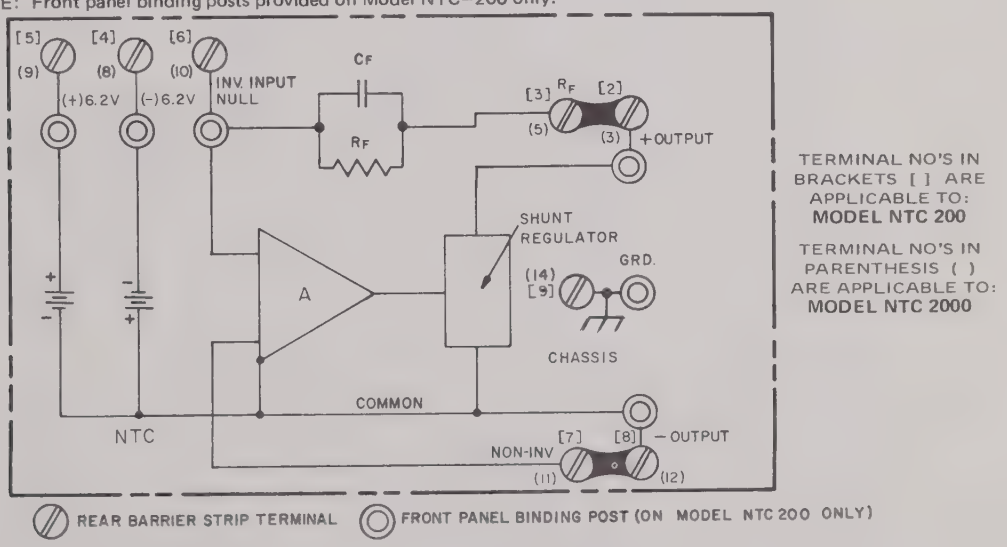


FIG. 3-1 FRONT AND REAR CONNECTIONS, NTC MODELS.

b) Connecting wires or cables must be properly insulated and terminated to make accidental touch impossible.

c) The maximum output voltage of the NTC appears also at the feedback terminals (between NULL and plus [+] OUTPUT). Consequently, any additional components connected to these terminals must be rated to withstand at least the maximum rated output voltage.

d) Refer to Section II (par. 2-6) for grounding instructions.

3-4 INITIAL ADJUSTMENTS

3-5 GENERAL. Built-in trim rheostats provide for the nulling of the fixed or initial offsets at the amplifier inputs. The procedure outlined below should precede each application to insure programming accuracy and to minimize errors.

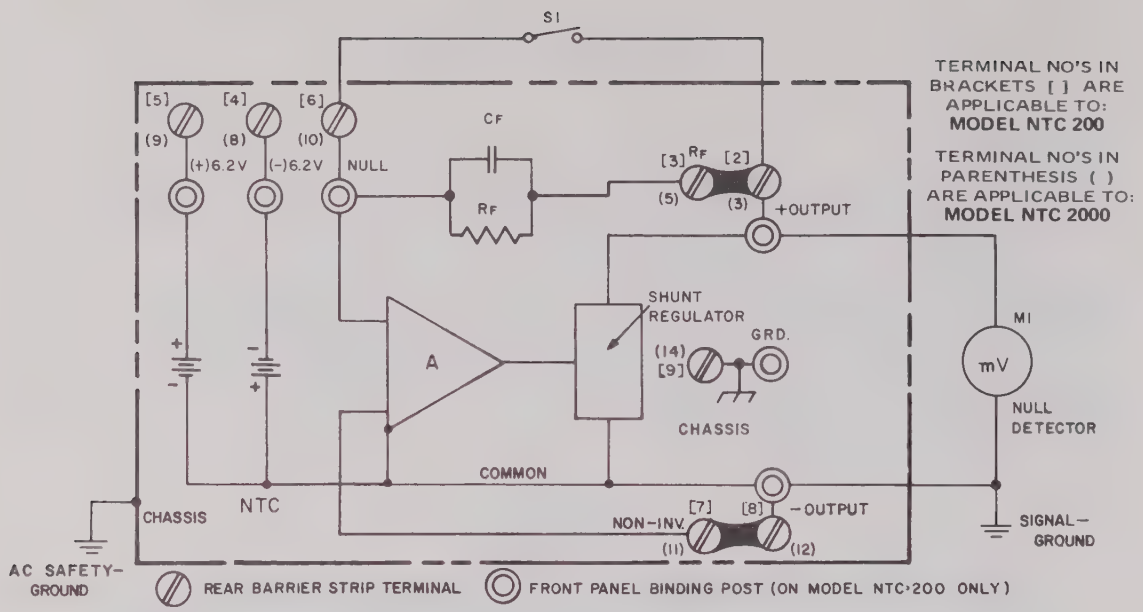


FIG. 3-2 OFFSET NULLING CIRCUIT.

3-6 PROCEDURE

a) Connect external components as shown in the diagram. (Refer to FIG. 3-2.) The "Null Detector" (M1) should be a sensitive instrument such as the MILLIVAC Model MV–07C or a digital meter. The shorting switch (S1) may be replaced by a shorting wire.

b) OFFSET VOLTAGE NULLING (S1 CLOSED). Turn NTC "on" and allow sufficient warm-up time until instruments have reached thermal equilibrium. Locate the offset controls. (Refer to Section II, FIG. 2-1.) Observe the "Null Detector" (M1) at the output and gradually increase the sensitivity of the meter. Adjust "E_{io} Null" (R12) until the "Null Detector" (M1) reads "zero."

c) OFFSET CURRENT NULLING (S1 OPEN). Observe the "Null Detector" (M1) and increase its sensitivity while adjusting "I_{io} Null" (R15) to "zero."

d) The adjustment may shift slightly as the NTC and the "Null Detector" are reaching thermal balance. Repeat adjustments as necessary.

3-7 PROGRAMMING WITH THE NTC (NEGATIVE GOING INPUT SIGNAL)

3-8 After the offset adjustments have been completed, the NTC is ready for interconnection with the associated power supply in the system. The setup diagram (FIG. 3-3) shows a complete programming system with all necessary interconnections.

3-9 Notice that all equipment cases are safely connected to a-c ground, and that a single signal or system ground point is established by grounding the NEGATIVE output of both the NTC and the associated power supply. The signal source POSITIVE is also connected to this common signal ground so that the signal source can now be operated close to ground potential.

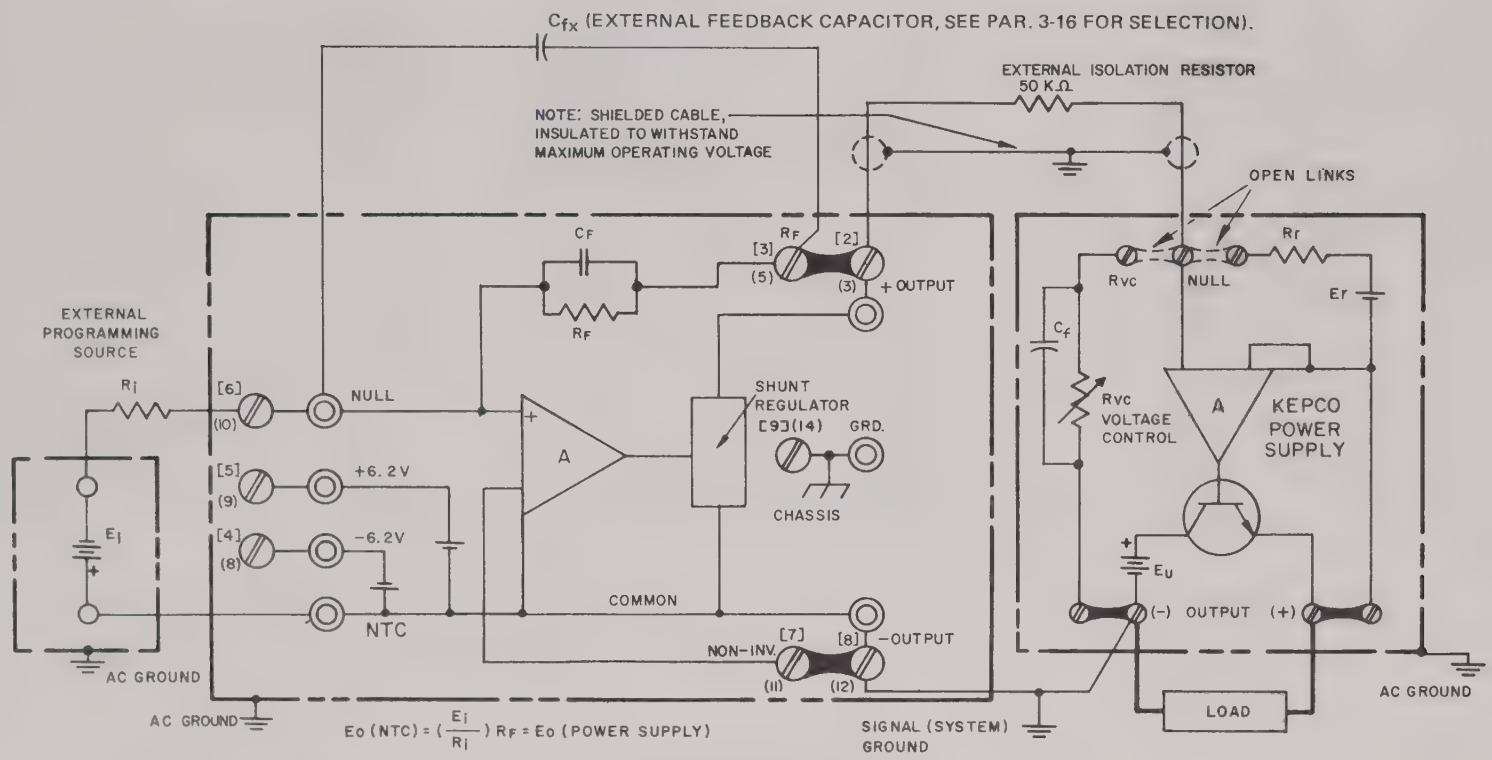
3-10 All suitable programming examples which are described in the individual instruction manual for the associated power unit are fully applicable. All equations for the calculation of programming components can be used, except that the input polarity of the signal source and the output polarity of the power supply are reversed. The total transfer functions for the system can be expressed by:

$$E_o \text{ (Power Supply Unit)} = E_o \text{ (NTC)} = (-)\left(\frac{E_i}{R_i}\right) R_f \text{ where:}$$

E_i = Programming voltage (Negative with reference to COMMON)

R_i = Input resistance

R_f = 2 megohms for NTC–2000, 200 K ohms for NTC–200



TERMINAL NO'S IN BRACKETS [ ] ARE APPLICABLE TO: **MODEL NTC 200**

TERMINAL NO'S IN PARENTHESIS ( ) ARE APPLICABLE TO: **MODEL NTC 2000**

NOTE: Front panel binding posts provided on Model NTC–200 only.

FIG. 3-3 COMPLETE PROGRAMMING SET-UP (NEGATIVE GOING INPUT SIGNAL).

3-11 PROGRAMMING WITH THE NTC (POSITIVE GOING INPUT SIGNAL)

3-12 For applications where the polarity of the available input signal is POSITIVE with respect to COMMON (−output), the noninverting input of the NTC can be used to achieve the desired results (refer to FIG. 3-4). The transfer function for the system (connected as shown in FIG. 3-4) can now be expressed by the equation:

$$E_O \text{ (Power Supply)} = E_O \text{ (NTC)} = E_i (1 + R_f/R_i),$$

where: E_i = Programming Voltage (POSITIVE with reference to COMMON).
R_i = Input resistance, depending on the magnitude of E_i and to be calculated by the equation above.
R_f = 2 megohoms for NTC−2000, 200 K ohms for NTC−200.

3-13 Example for calculating R_i: Let the input be a positive going sawtooth wave with an amplitude of 10V, and let the desired power supply output be 150V. Then E_i = 5V, E_O = 150V, R_{VC} = 200 K (NTC−200), so that:

$$E_O/E_i = 30 = 1 + \frac{200K}{R_i}, \text{ and } R_i \approx 6.9 \text{ K ohm.}$$

NOTE: The input voltage (E_i) for programming the noninverting input of the NTC must be restricted to ***positive*** voltage signals with a maximum peak value of 5 volts.

3-14 A-C STABILITY ADJUSTMENT

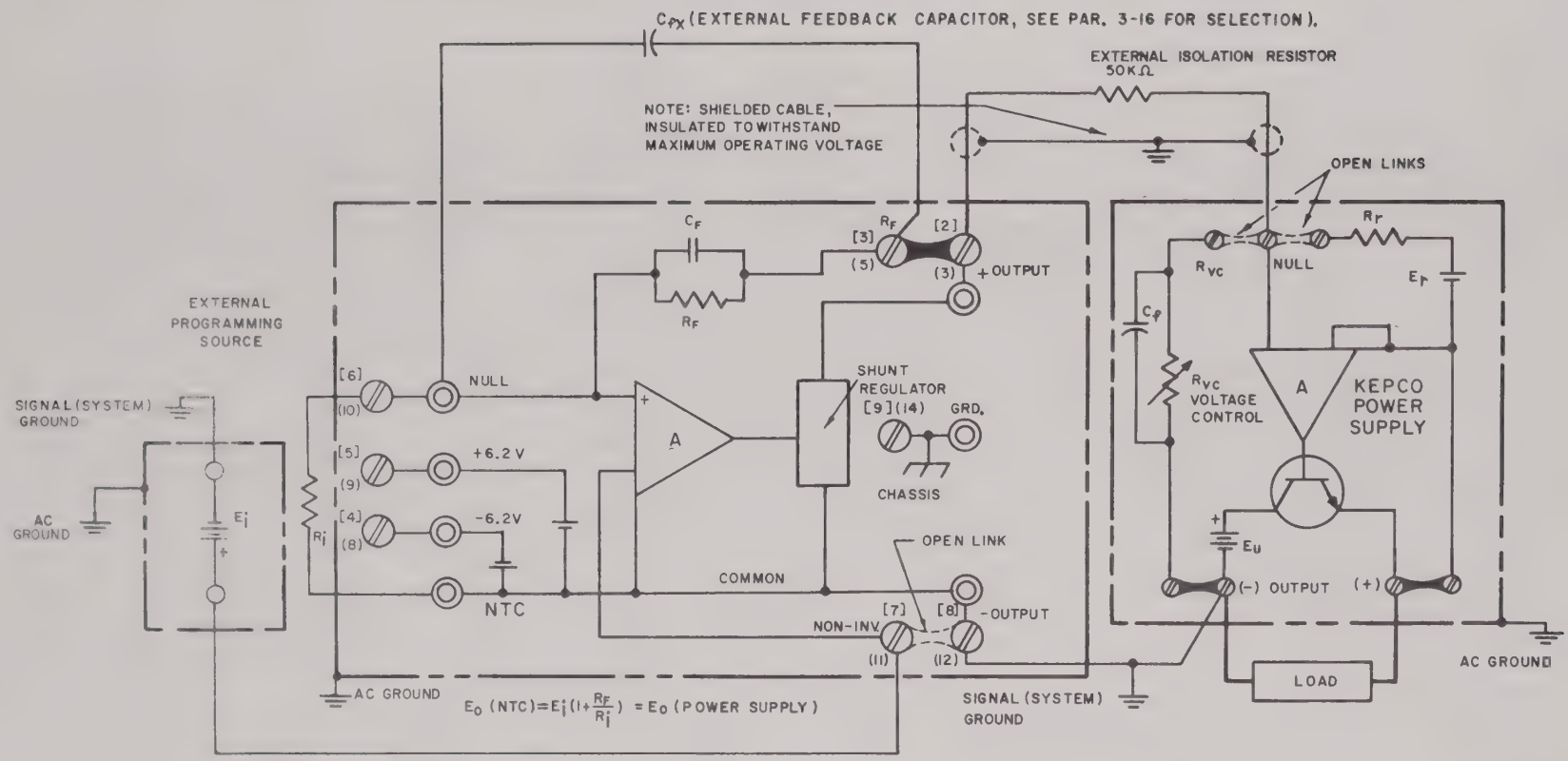
3-15 All NTC models are equipped with an "A-C Stability" adjustment, accessible through the slot on the front panel. In case of dynamic instability (oscilliation) as observed with an oscilloscope across the load, this control should be adjusted to restore stable output.

3-16 PROGRAMMING "SLOW SPEED" POWER SUPPLIES

3-17 When a "slow speed" power supply is programmed via the NTC device, an additional, external feedback capacitor and/or an isolation resistor must be connected as indicated in FIG. 3-3 and FIG. 3-4 to avoid dynamic instability. The reason for this behavior is that the internal feedback capacitor (C_f) of the power supply capacitively loads the NTC interface device. If this capacitive load exceeds the maximum specified for the NTC, instability will result The capacitive load, must therefore, be isolated and/or compensated by the external capacitor (C_f external) and/or the external isolating resistor. The isolation resistor should be connected first. If instability persists, connect the external capacitor. The external capacitor should be selected experimentally for the lowest value which will stabilize the output. NOTE: For the NTC−2000, the capacitor must have voltage rating of at least 2000 volts (200 volts for NTC−200).

3-18 NTC WITH EXTERNAL FEEDBACK

3-19 The built-in feedback resistor (R_f) together with the feedback capacitor (C_f) may be disconnected from the positive output terminal (+ OUT) of the NTC. The NTC may then be used with other values of feedback resistance, or it may be operated in an "open loop" configuration. A new value of feedback capacitor (C_f) must be selected and connected for every new value of feedback resistance (R_f). The new value of (C_f) should be determined experimentally.



TERMINAL NO'S IN BRACKETS [ ] ARE APPLICABLE TO: **MODEL NTC 200**

TERMINAL NO'S IN PARENTHESIS ( ) ARE APPLICABLE TO: **MODEL NTC 2000**

NOTE: Front panel binding posts provided on Model NTC–200 only.

FIG. 3-4 COMPLETE PROGRAMMING SET-UP (POSITIVE GOING INPUT SIGNAL).

SECTION IV – THEORY OF OPERATION

4-1 GENERAL

4-2 Most modern, full range programmable, d-c regulated power supplies make use of NPN transistors or vacuum tubes for the series regulating element (pass element). This fixes their OUTPUT polarity as NEGATIVE and their INPUT polarity as POSITIVE with respect to their COMMON input/output lead. (Refer to FIG. 4-1).

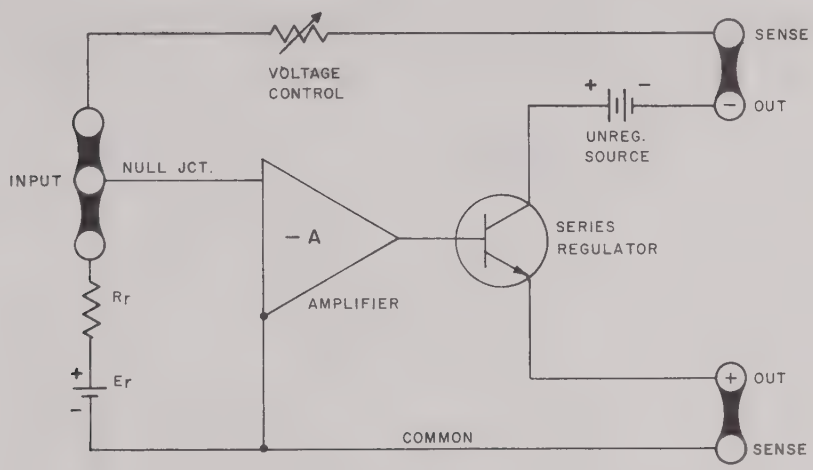


FIG. 4-1 SIMPLIFIED SCHEMATIC, REGULATED POWER SUPPLY.

4-3 Kepco power supply isolation specifications permit grounding either output (most devices can, in fact, be "floated" several hundred volts above ground), but external signal sources, connected between the power supply "input" and "common," do not always have the necessary isolation voltage if the NEGATIVE power supply output must be grounded. (Refer to FIG. 4-2.)

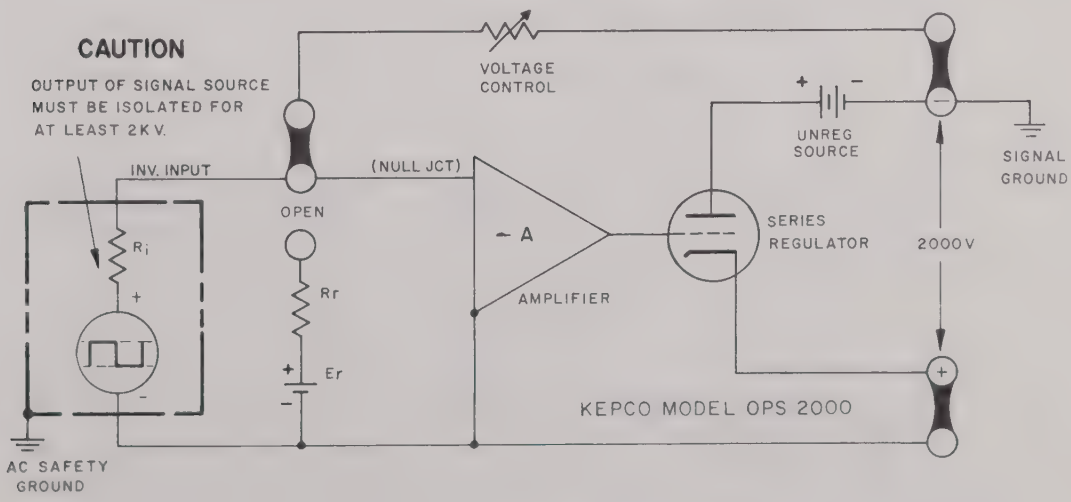


FIG. 4-2 VOLTAGE PROGRAMMING THE POWER SUPPLY.

4-4 Kepco NTC devices were specifically designed to provide a convenient interface in such cases where the negative terminal of the power supply must be returned to signal ground and the programming source does not have sufficient isolation to operate in this manner. In effect, the Kepco NTC device provides a "polarity reversal," i.e., the COMMON terminal is now the NEGATIVE output and can be grounded together with the POSITIVE terminal of the input source. (Refer to FIG. 4-3.)

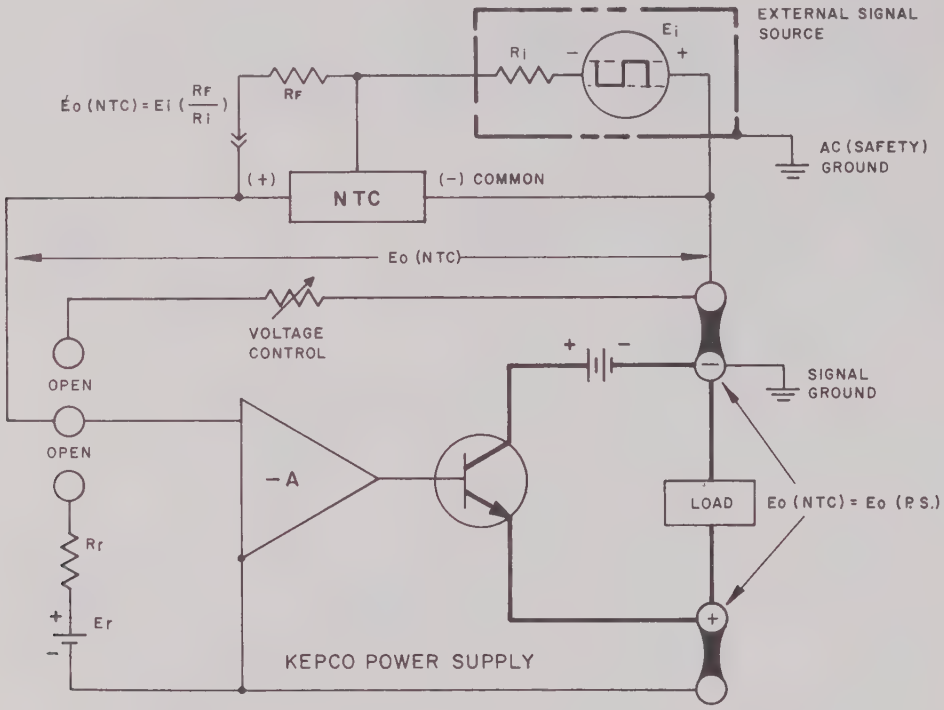


FIG. 4-3 POLARITY REVERSAL WITH THE KEPCO NTC PROGRAMMER.

4-5 While the NTC device is programmed by either its internal reference and/or external input sources, the associated power supply serves as a "voltage repeater" or "impedance transformer," faithfully reproducing the voltage of the NTC device but able to deliver its rated output current. Since the output voltage of the associated power supply is exactly equal to that of the connected NTC device, the total transfer function for the system connected as shown (refer to FIG. 4-3) can be expressed as:

$$E_o\,(\text{POWER SUPPLY}) = E_o\,(\text{NTC}) = -E_i\left(\frac{R_f}{R_i}\right), \quad \text{(Eq. 1)}$$

where "E_i" is the amplitude of the external programming source, "R_i" is the input resistance, "R_f" is the fixed feedback resistor of the NTC (2 megohms for Model NTC–2000, 200 K ohms for Model NTC–200), and the ratio "R_f/R_i" constitutes the closed-loop gain of the NTC. Another useful form of the above expression (Eq. 1) may be written as:

$$E_o\,(\text{POWER SUPPLY}) = E_o\,(\text{NTC}) = I_b R_f \quad \text{(Eq. 2)}$$

where $I_b = E_i/R_i$, the programming current from the external source. The dissipation rating of the built-in feedback resistor (R_f) allows a maximum programming current (I_b) of about 1 mA; in fact, the value of R_f is designed such that 1 mA of I_b results in the maximum rated output voltage:

a) Model NTC–2000, R_f = 2 megohms, $E_{o\ max.} = I_b R_f$ = 1 mA (2 megohms) = 2000V.

b) Model NTC–200, R_f = 200 K ohms, $E_{o\ max.} = I_b R_f$ = 1 mA (200 K ohms) = 200V.

4-6 Equations (1) or (2) may be used to calculate the input resistor (R_i) which together with the amplitude of the programming source (E_i) determines the output voltage. If, for example, a Model NTC–2000 is to be voltage programmed from a variable input source capable of supplying at least 1 mA and with a peak output voltage of 0 to 10V and the full output voltage of the NTC is required, R_i is calculated using Equation (1):

$E_O = \frac{E_i}{R_i} R_f$. Since in this case: $R_f = 2$ megohms, $E_i = 10$ volts, $E_O = 2000$ volts

$$R_i = \left(\frac{R_f}{E_O}\right) E_i = \frac{2 \times 10^6 \text{ ohms (10 volts)}}{2 \times 10^3 \text{ volts}} = 1 \times 10^4 \text{ ohms.}$$

The same result could of course have been obtained by considering the voltage gain requirements. Since the required closed-loop gain is $E_O/E_i = 2000V/10V = 200$ the ratio R_f/R_i must also equal 200. Since $R_f = 2$ megohms, R_i is given by 2×10^6 ohms/200 = 1×10^4 ohms = 10 K ohms.

4-7 EQUIVALENT CIRCUIT ANALYSIS

4-8 The Kepco NTC Power Supply is basically a shunt-regulated device controlled by an integrated circuit amplifier with associated driver stage. The amplifier input can be externally programmed to vary the output voltage from zero to the maximum rated output voltage of the NTC. (See FIG. 4-4.)

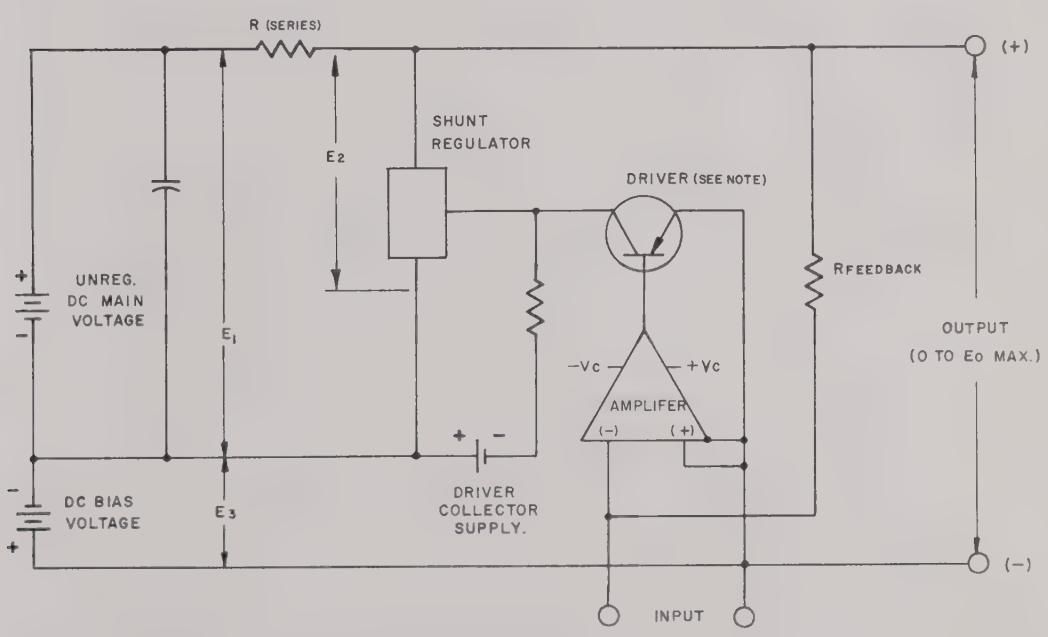


FIG. 4-4 NTC EQUIVALENT CIRCUIT.

*DRIVER STAGE USED IN NTC–2000 ONLY. IN MODEL NTC–200, AMPLIFIER DRIVES THE SHUNT REGULATOR DIRECTLY.

4-9 The transfer function of the NTC is synthesized by means of the internal feedback resistor (R_f), the external input resistor (R_i) and the gain of the amplifier. If the latter is very high, the transfer function can be approximated by:

$E_O = -E_i \left(\frac{R_f}{R_i}\right)$ where: E_O = Output voltage, NTC
E_i = External programming voltage
R_f = Internal feedback resistance
R_i = External input resistance

(See also paragraphs 4-4, 4-5 in this section.)

4-10 The shunt-regulating element in the NTC varies its conductance in response to the amplified input signal. As seen in the equivalent circuit (FIG. 4-4), a bias supply (E_3) in series with the main supply (E_1) is provided in order to allow the output voltage (E_O) to reach zero volts. In case of a "zero voltage" command from the control circuitry, the shunt regulator conducts heavily. Without the bias voltage (E_3), the output voltage would not be zero, but consist of the voltage drop across the shunt regulator (E_2). Since, however, the shunt regulator drop is in series with and of opposite polarity than the bias supply ($E_2 = -E_3$), the output voltage is zero volts ($E_O = 0$). The difference voltage between the unregulated supply (E_1) and the shunt regulator voltage drop (E_2) is always applied across the series resistor (R_S). The amplifier is supplied with independent operating voltages from other windings of the auxiliary transformer (T202).

4-11 CIRCUIT DESCRIPTION (Refer to Main Schematic, FIG. 6-3.)

4-12 The circuitry of the NTC Power Supply is located on two printed circuit boards (A1, A3) except for the main transformer (T201), the auxiliary transformer (T202), the front panel components (S101, DS101) and the fuse (F201) which are part of the chassis assembly (A2). The PCB assemblies (A1, A3) and the chassis components are interconnected by means of PCB connectors which are part of the distribution wiring harness. Reference designations of all components are related to their assembly numbers:

A1 – MAIN PCB ASSEMBLY, COMPONENT NUMBERS (1) to (99).

A2 – CHASSIS ASSEMBLY WITH FRONT PANEL, COMPONENT NUMBERS (201) to (299).

A3 – RECTIFIER ASSEMBLY, COMPONENT NUMBERS (301) to (399).

By means of its reference designation, each component can therefore be readily traced from the main schematic (FIG 6-3) to its location on the component location drawings (FIGS. 6-1, 6-2) and finally to its physical location in the power supply.

4-13 For the purpose of analysis, the circuitry is divided into several functional sections which are subsequently described below:

a) A-C INPUT CIRCUIT. The a-c input power is introduced by means of a detachable 3-wire safety cord with polarized plug. With the use of this cord and a grounded a-c outlet, the power supply is automatically a-c "safety" grounded since one wire of the safety cord is directly connected to the metal chassis and cover. Once the a-c power switch (S101) is activated, the a-c power indicator (DS101) will energize, and input power is applied to the primary of T202 and the time delay circuit. The primary winding on T202 is tapped and can either be connected for 115V a-c service or for 230V a-c service. After approximately 30 seconds, the time delay circuit will transfer a-c input power to the main transformer (T201). The main fuse (F201) protects the primary circuits from reflected overloads. Any interruption of the a-c input source to the power supply will deenergize the time delay circuit and will require a new 30 second timing cycle as described before.

b) MAIN D-C VOLTAGE SUPPLY. This supply provides the output current and the operating voltage for the shunt regulator (V1). The supply is derived from the secondary winding on the main transformer (T201), full-wave rectified by the bridge rectifier circuit (CR301, 302, 303, 304) and capacitor-filtered by C201. The d-c voltage is applied to the shunt regulator in series with the power resistors (R302 through R306).

c) SHUNT REGULATOR STAGE. The shunt regulator tube (V1), receiving filament power from a separate winding on T202, is connected in parallel with the main d-c voltage and in series with the bias supply. The conductance of V1 is changed in response to driver signals. If the input to the NTC is a d-c reference level, the output voltage is kept constant with respect to this reference level regardless of variations in the a-c power source or changes in d-c load since these changes are sensed by the feedback resistor, transferred to the amplifier input, amplified as an error signal and (via the driver) command the shunt regulator to alter its conductance such that the original output voltage error is corrected. If the input to the NTC is a variable signal, the output voltage reproduces the input signal (amplified by the ratio R_f/R_i see par. 4-7) since the shunt regulator responds exactly to the amplified driver signal applied to its control grid.

d) AMPLIFIER AND DRIVER STAGE. The integrated circuit amplifier (IC-1) is used in the inverting configuration. The input terminal (NULL JUNCTION) is terminated at the rear barrier strip (T201—10). It will accept NEGATIVE input voltages resulting in POSITIVE NTC output with reference to the COMMON terminal. The amplifier is carefully compensated for its initial offset voltage (E_{io} Null, R12) and offset current (I_{io} Null, R15). IC-1 operates directly into the driver stage (Q4) which provides the necessary voltage swing for the control of the shunt regulator.

e) AUXILIARY D-C VOLTAGE SOURCES.

1) BIAS AND DRIVER COLLECTOR SUPPLY. The center-tapped secondary winding on T202 provides the basis for these two d-c sources. The full wave rectifier (CR3,4,5,6) provides for the raw d-c voltage filtered by C4 and C5 to establish the d-c bias, as well as the collector voltage for Q4. The bleeder resistors (R3, R4) discharge the filter capacitors after shutdown of the NTC.

2) AMPLIFIER POWER SUPPLY. Derived from another secondary winding on T202, the raw d-c is provided by the bridge rectifier (CR7) and capacitor filter C3. A constant current stage (Q2), feeding zener sources (CR12, 13) provides the operating potential for the amplifier (IC-1) and the reference sources (CR20, 21). These very stable voltages (±6.2 volt nominal with respect to common) are available at the rear barrier strip (TB201—8,9). These sources can be used for signal biasing, level shifting or d-c reference purposes. The zener diodes (CR20, 21) are thermally stabilized at a load current of 1mA ±10%, the given specifications (see Section I) are valid only for this value. Smaller currents from these reference sources can be drawn by making up the difference between the drawn current and the specified 1mA by paralleling the reference source with an additional resistor. For larger reference currents, an external source must be used.

f) TIME DELAY CIRCUIT. The purpose of this circuit is to delay the plate voltage to the regulating tube (V1) until its filaments have reached the proper operating temperature. The a-c input to the half-wave rectifier circuit (CR1, R1, C1) is always 115V, even if T202 is connected for 230V operation. The rectifier d-c voltage is held constant by the zener diode (CR2). The RC time constant of R5 and C2 determines the turn-on time of the unijunction oscillator stage (Q1). Q1 delivers the turn-on signal for CR11, which in turn supplies a constant turn-on current (via Q3) to the triac (CR14). Since CR14 is in series with the primary winding of T201, it keeps T201 "on", as long as power is supplied to the delay circuit. An interruption of a-c input power will necessitate the start of a new turn-on sequence and therefore another time delay period (30 seconds).

SECTION V – MAINTENANCE

5-1 GENERAL

5-2 This section covers maintenance procedures for Kepco NTC Power Supplies. Conservative ratings of components and noncongested layout should keep maintenance to a minimum. If trouble does develop, however, the wrap-around cover and the plug-in feature of the main component boards provide exceptional accessibility of the circuitry.

5-3 COVER REMOVAL

5-4 The wrap-around cover may be easily removed by loosening the 2 black nickel screws on the front panel and the holding screws on each side of the unit. (NTC–2000 has 3 and NTC–200 has 4 holding screws on each side.)

5-5 TROUBLE SHOOTING

5-6 The repair of precision power supplies and operational amplifiers requires a thorough understanding of the operational concept, experience with solid-state circuitry and appreciation of the problems encountered in closed-loop systems. Repairs beyond simple part replacement and recalibration should therefore be handled only by competent personnel. "Trouble Shooting Charts" giving resistance and voltage ratings at various parts in the circuitry are of little value in feedback amplifiers and for this reason are not included here. Presented instead are:

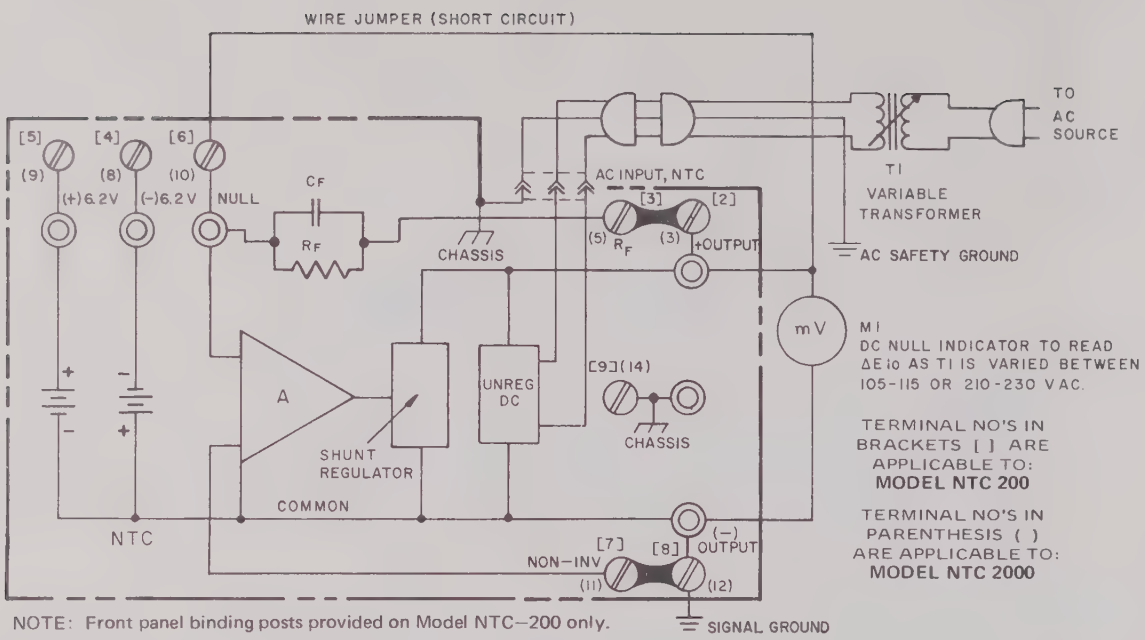
a) Extensive Operational Theory (Section IV).
b) Parts Location Diagrams (FIGS. 6-1, 6-2).
c) Main Schematic with voltage readings on all essential points (FIG. 6-3).
d) Parts List (Section VI).
e) Circuit Description (Section IV).

It has been our experience that this material will provide the necessary information in the majority of all cases of equipment failure if handled by competent personnel. Kepco Field Engineering Offices and the Kepco Repair and Engineering Applications Departments are always available for prompt service in difficult cases.

5-7 TEST MEASUREMENTS

5-8 GENERAL. Test measurements to verify the specifications of the operational power supply are often required as a part of incoming inspection, following repairs or as a part of a regular maintenance procedure. Adequate test facilities and equipment as well as great care in the performance of these measurements are of prime importance to insure valid results. Since many measurements on operational power supplies and amplifiers require specialized test equipment and rigidly controlled environment conditions, only the more readily verifiable ones are described here.

5-9 D-C MEASUREMENTS. Variations of the offset voltage (ΔE_{io}) and offset current (ΔI_{io}) with a-c input source changes over the specified range are an excellent indication of the d-c performance of the operational power supply. These measurements may be readily duplicated by following the instructions and diagrams below.



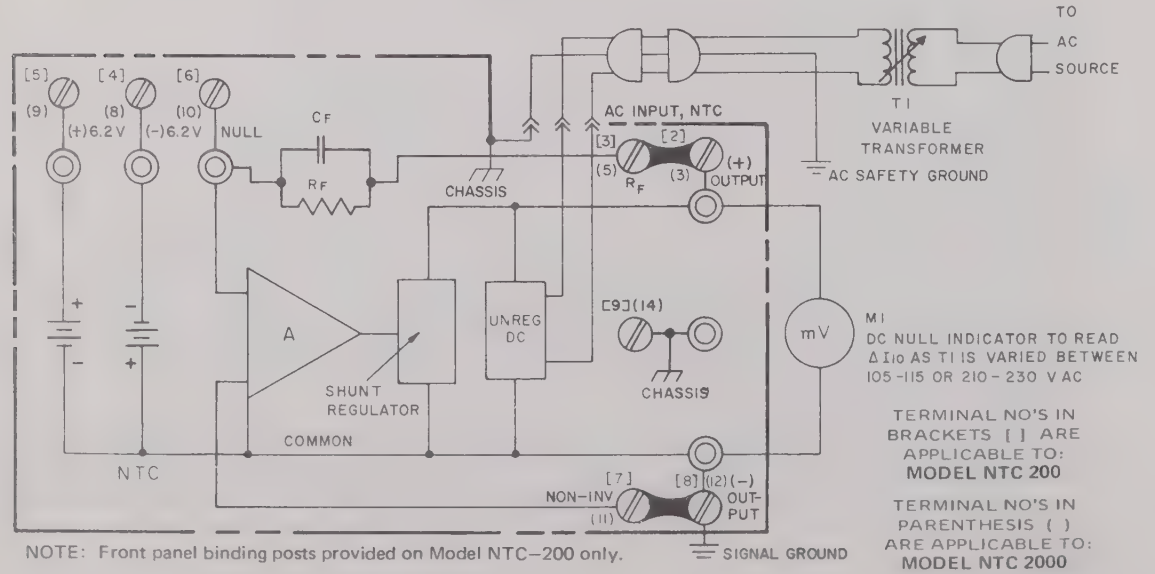
NOTE: Front panel binding posts provided on Model NTC−200 only.

FIG. 5-1 D-C TEST MEASUREMENTS (ΔE_{io}).

a) VARIATIONS IN OFFSET VOLTAGE (ΔE_{io}). Measurements are made with the circuit shown in FIG. 5-1. Since the feedback terminals are shorted out ($R_f = 1$), and the input is disconnected, the operational gain is unity. Whatever offset voltage exists between null junction and common will be transferred directly to the output. Monitoring the output by means of a sensitive null detector while varying the a-c input source (or temperature or time, if facilities permit) will allow measurement of ΔE_{io} at the output.

b) VARIATIONS IN OFFSET CURRENT (ΔI_{io}). Measurements are made with the circuit shown in FIG. 5-2. Since the offset current will have to flow through the feedback resistor, it produces an output voltage ΔE_o which is equal to $\Delta I_{io} R_f$. The variations in offset current (ΔI_{io}) are given by monitoring ΔE_o while varying the a-c input source (or temperature or time, if facilities permit) and dividing the result by the value of the feedback resistor (R_f):

$$\Delta I_{io} = \Delta E_o / R_f$$



NOTE: Front panel binding posts provided on Model NTC−200 only.

FIG. 5-2 D-C TEST MEASUREMENTS (ΔI_{io}).

5-10 DYNAMIC MEASUREMENTS. The specifications for the PROGRAMMING TIME CONSTANT and for the MAXIMUM SLEWING RATE can be verified using the circuit shown in FIG. 5-3.

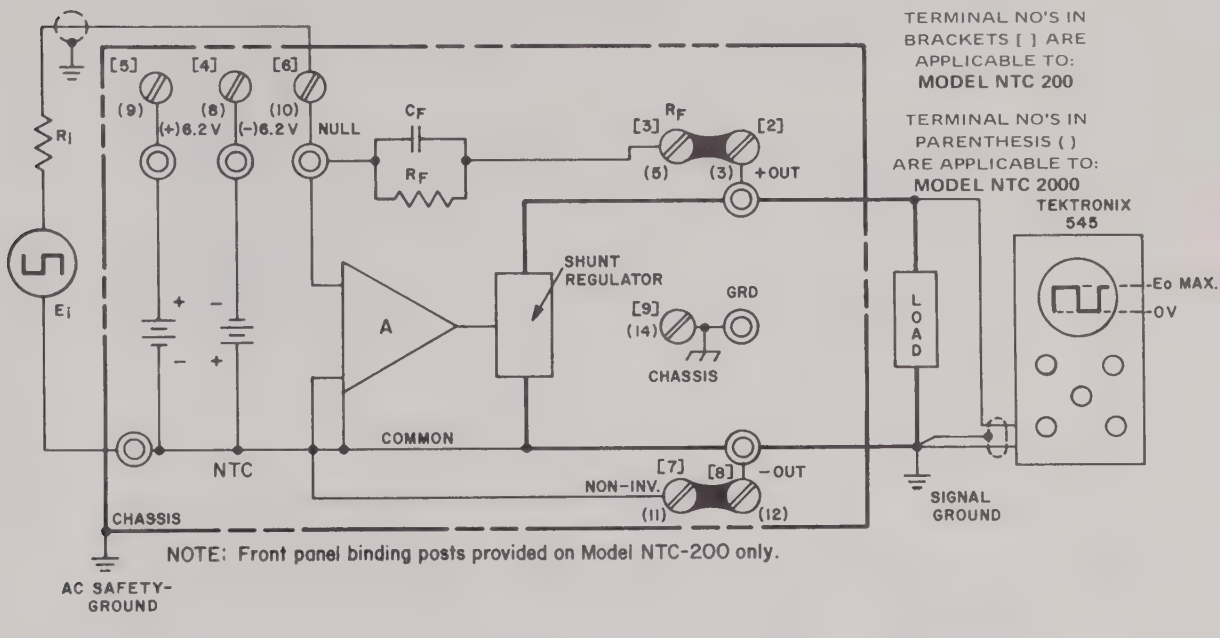


FIG. 5-3 TEST SETUP FOR DYNAMIC MEASUREMENTS.

5-11 PROCEDURE (Refer to FIG. 5-3)

1) To measure the PROGRAMMING TIME CONSTANT, adjust the gain of the square-wave generator (E_i) until the output waveform (displayed on the oscilloscope) shows a peak amplitude equal to the maximum rated output voltage of the NTC model under test. (Refer to FIG. 5-4.) NOTE: Use *inverted* oscilloscope input.

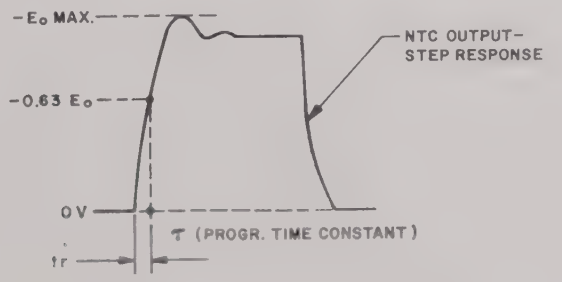


FIG. 5-4 NTC OUTPUT WAVEFORM FOR TIME CONSTANT MEASUREMENTS

NOTE: Measure the rise time of the displayed waveform from zero (0V) to $-0.63\ E_O$ = ONE TIME CONSTANT) This rise time (T_r) represents the PROGRAMMING TIME CONSTANT.

2) To measure the MAXIMUM SLEWING RATE, ***increase*** the gain of the square-wave generator at the input (E_i) until a ***distinct break point*** in the up-slope of the output waveform becomes visible. The slope from "0V" to this break point is the fastest rate of change of which the NTC under test is capable. Make certain that this is true by slightly increasing the gain of the square-wave generator. The slope (E_o/t_r) should not change. (Refer to FIG. 5-5).

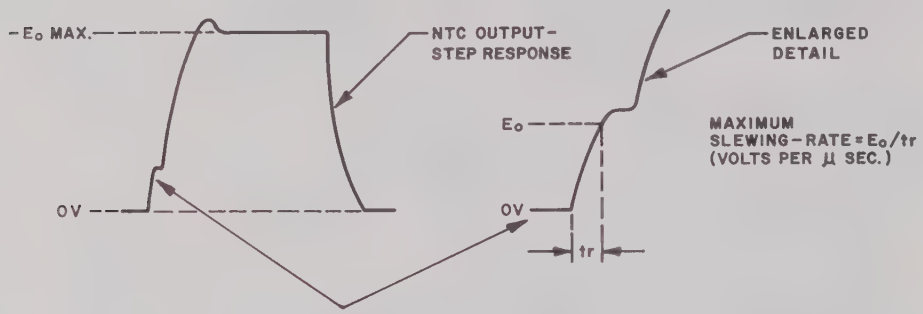


FIG. 5-5 OUTPUT WAVEFORM FOR SLEWING RATE MEASUREMENTS.

NOTE: 1) MEASURE "E_o" (ANY CONVENIENT VALUE ON THE SLOPE).
2) MEASURE "t_r."
3) CALCULATE: MAXIMUM SLEWING RATE = E_o/t_r in volts per microseconds.

SECTION VI – ELECTRICAL PARTS LIST AND DIAGRAMS

6-1 GENERAL

6-2 This section contains the main schematic, the parts location diagrams, and a list of all replaceable electrical parts. All components are listed in alpha-numerical order of their reference designations. Consult your Kepco Representative for replacement of parts not listed here.

6-3 ORDERING INFORMATION

6-4 To order a replacement part or to inquire about parts not listed in the parts list, address order or inquiry either to your authorized Kepco Sales Representative or to:

KEPCO, INC.
131–38 Sanford Avenue
Flushing, N.Y. 11352

6-5 Specify the following information for each part:

a) Model and complete serial number of instrument.

b) Kepco part number.

c) Circuit reference designator.

d) Description.

6-6 To order a part not listed in the parts list, give a complete description and include its function and location.

NOTE: KEPCO DOES NOT STOCK OR SELL COMPLETE POWER SUPPLY SUBASSEMBLIES AS DESCRIBED HERE AND ELSEWHERE IN THIS INSTRUCTION MANUAL. SOME OF THE REASONS ARE LISTED BELOW:

1) Replacement of a complete subassembly is a comparatively rare necessity.

2) Kepco's subassemblies are readily serviceable, since most of them are of the "plug-in" type.

3) All active components are socket mounted, making replacement extremely easy.

4) The nature of a closed-loop power supply system requires that subassembly replacement is followed by careful measurement of the total power supply performance. In addition, depending on the function of the subassembly, extensive alignment may be required to restore power supply performance to specified values.

IF REPAIRS INVOLVING SUBASSEMBLY REPLACEMENTS ARE REQUIRED, PLEASE CONSULT YOUR LOCAL KEPCO REPRESENTATIVE OR THE KEPCO SALES ENGINEERING DEPARTMENT IN FLUSHING, NEW YORK, N.Y.

ABBREVIATIONS USED IN KEPCO PARTS LISTS

A) Reference Designators:

A = Assembly
B = Blower (Fan)
C = Capacitor
CB = Circuit Breaker
CR = Diode
DS = Device, Signaling (Lamp)
F = Fuse
FX = Fuse Holder
IC = Integrated Circuit
J = Jack
K = Relay
L = Inductor
LC = Light-Coupled Device
M = Meter
P = Plug
Q = Transistor
R = Resistor
S = Switch
T = Transformer
TB = Terminal Block
V = Vacuum Tube
X = Socket

B) Description Abbreviations

A = Ampere
AC = Alternating Current
AMP = Amplifier
AX = Axial
CAP. = Capacitor
CER = Ceramic
CT = Center-Tap
°C = Degree Centigrade
FXD = Fixed
Ge = Germanium
H = Henry
Hz = Hertz
IC = Integrated Circuit
K = Kilo (10^3)
m = Milli (10^{-3})
M = Mega
MFR = Manufacturer
MET. = Metal
n = Nano (10^{-9})
NC = Normally Closed
NO = Normally Open
P = Pico (10^{-12})
PC = Printed Circuit
POT = Potentiometer
PIV = Peak Inverse Voltage
p-p = Peak to Peak
ppm = Parts Per Million
PWR = Power
DC = Direct Current
DPDT = Double Pole, Double Throw
DPST = Double Pole, Single Throw
ELECT = Electrolytic
F = Farad
FILM = Polyester Film
FLAM = Flammable
°F = Degree Farenheit
RAD = Radial
RECT = Rectifier
REG = Regulated
RECY = Recovery
RES = Resistor
RMS = Root Mean Square
Si = Silicone
S-End = Single Ended
SPDT = Single Pole, Double Throw
SPST = Single Pole, Single Throw
TAN = Tantalum
TSTR = Transistor
u = Micro (u) (10^{-6})
VAR = Variable
V = Volt
W = Watt
W.W. = Wire Wound

KEPCO® REPLACEMENT PARTS LIST

PRINTED CIRCUIT BOARD ASSEMBLY (A1), MODEL NTC 2000 **Code 4-1478**

REFERENCE DESIGNATION	QTY.	DESCRIPTION	MFRS. NAME & PART NO. SEE BOTTOM NOTE	KEPCO PART NO.	REC. SPARE PART QTY.
IC1	1	Fet. Input Op-Amp	National LF355P	250-0083	1
C1	1	Capacitor, Elect., Axial Leads 22uF, 100V, +75, -10%	General Electric Type 76F	117-0490	1
C2	1	Capacitor, Elect., Axial Leads 22uF, 25V, 20%	General Electric Type 76F	117-0503	1
C3	1	Capacitor, Elect., Axial Leads 350uF, 50V, +75, -10%	Sprague Type 38D	117-0619	1
C4,5	2	Capacitor, Elect., Axial Leads 200uF, 150V, +100, -10%	General Electric Type 43F	117-0440	1
C6	1	Capacitor, Elect., Axial Leads 10uF, 100V, +50, -10%	General Electric Type 76F	117-0439	1
C7	1	Capacitor, Mylar, Axial Leads 1uF, 200V, 5%	Wesco Type 33 MPC	117-0520	1
C8	1	Capacitor, Ceramic Disc .005uF, 500V, 10%	Radio Materials Type SM	117-0061	1
C9	1	Capacitor, Ceramic Disc 500pF, 2000V, 10%	Radio Materials Type U	117-0070	1
C10	1	Capacitor, Mylar, Axial Leads 0.001uF, 200V, 10%	Sprague Type 192P	117-0570	1
CR1	1	Rectifier, Silicon, Axial Leads 1KV (PIV), 1A	Semicon, Inc. SI-10	124-0094	1
CR2	1	Zener Diode, Axial Leads 18V, 5%, 1W	International Rectifier Corp. 1N3026B	121-0036	1
CR3,4,5,6, 15,16,19	7	Rectifier, Silicon, Axial Leads 400V (PIV), 1A	Semicon, Inc. SI-4	124-0028	2
CR7	1	Rectifier, Silicon, Bridge 200V (PIV), 1A	Varo VE-28	124-0346	1
CR8,17,18	3	Zener Diode, Axial Leads 6.5V, 5%, 250mW	Transitron 1N763-1	121-0028	1
CR9	1	Rectifier, Silicon, Axial Leads 100V (PIV), 1A	Semicon, Inc. SI-1	124-0133	1
CR10	1	Zener Diode, Axial Leads 3.3V ±5%, 400mW	Transitron 1N746A	121-0060	1
CR11	1	Thyristor, SCR 30V (V_R), 0.8A	Motorola 2N5060	124-0429	1
CR12,13	2	Zener Diode, Axial Leads 12V, 10%, 1W	Motorola 1N4742	121-0012	1
CR14	1	Thyristor, Triac 200V (V_R), 0.35A	RCA 40691	124-0428	1
CR20,21	2	Zener Ref. Diode, Axial Leads 5.9–6.5V, 400mW	Motorola 1N821	121-0041	1
Q1	1	Transistor, Unijunction TO-92	Motorola 2N4870	119-0105	1
Q2	1	Transistor, PNP Small Signal, TO-5	RCA 2N3053	119-0059	1
Q3	1	Transistor, PNP Low Power, TO-92	Fairchild 2N5138	119-0096	1

NOTE: REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS REPRESENTS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN OBTAINING REPLACEMENT PARTS LOCALLY. WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC.

KEPCO. REPLACEMENT PARTS LIST

PRINTED CIRCUIT BOARD ASSEMBLY (A1), MODEL NTC 2000 **Code 4-1478**

REFERENCE DESIGNATION	QTY.	DESCRIPTION	MFRS. NAME & PART NO. SEE BOTTOM NOTE	KEPCO PART NO.	REC. SPARE PART QTY.
Q4	1	Transistor, PNP Small Signal	Fairchild 2N4888	119-0085	1
R1	1	Resistor, Fixed, Power, Axial 2K ohm, 10W, 5%	Ward Leonard 10X2000	115-0305	1
R2	1	Resistor, Fixed, Carbon 1K ohm, 1W, 10%	Allen Bradley GB1021	115-0066	1
R3,4	2	Resistor, Fixed, WW 10K ohm, 5W, 3%	Tepro TS-SN	115-1635	1
R5	1	Resistor, Fixed, Molded 560K ohm, 1/2W, 10%	Allen Bradley EB5645	115-0251	1
R6	1	Resistor, Fixed, Carbon 150 ohm, 1/2W, 10%	Allen Bradley EB1511	115-0543	1
R7	1	Resistor, Fixed, Carbon 27 ohm, 1/2W, 10%	Allen Bradley EB2701	115-0861	1
R8	1	Resistor, Precision, M.F. 237 ohm, 1/2W, 1%	Dale Type MFF-1/2	115-1964	1
R9	1	Resistor, Variable, Multiturn 2K ohm, 3/4W, 20%	Bourns Type 3059-Y	115-2032	1
R10	1	Resistor, Fixed, Molded 1K ohm, 1/4W, 10%	Allen Bradley CB1021	115-2238	1
R11	1	Resistor, Fixed, Molded 24K ohm, 1W, 5%	Allen Bradley GB2435	115-2297	1
R12	1	Resistor, Variable, Multiturn 100K ohm, 3/4W, 20%	Bourns Type 3059-Y	115-2044	1
R13	1	Resistor, Fixed, Molded 750 ohm, 1/2W, 5%	Allen Bradley EB7505	115-0566	1
R14	1	Resistor, Fixed, Molded 24K ohm, 1/2W, 5%	Allen Bradley EB2435	115-0506	1
R15	1	Resistor, Variable, Multiturn 25K ohm, 3/4W, 20%	Bourns Type 3059-Y	115-2056	1
R16	1	Resistor, Fixed, Molded 1K ohm, 1/2W, 10%	Allen Bradley EB1021	115-0547	1
R17	1	Resistor, Fixed, Molded 82K ohm, 1/2W, 5%	Allen Bradley EB8235	115-0253	1
R18	1	Resistor, Fixed, Molded 3.9K ohm, 1/2W, 10%	Allen Bradley EB3921	115-0921	1
R19	1	Resistor, Fixed, Molded 2.2K ohm, 1/2W, 5%	Allen Bradley EB2225	115-0339	1
R20	1	Resistor, Fixed, Molded 20K ohm, 1/2W, 5%	Allen Bradley EB2035	115-0555	1
R21	1	Resistor, Fixed, Molded 82K ohm, 1/2W, 10%	Allen Bradley EB8231	115-0776	1
R22	1	Resistor, Fixed, Molded 1K ohm, 1/2W, 5%	Allen Bradley EB1025	115-0340	1
R23	1	Resistor, Fixed, Molded 3K ohm, 1W, 5%	Allen Bradley GB3015	115-2164	1
R24	1	Resistor, Fixed, Precision, M.F. 4.99M ohm, 1/8W, 1%	Pyrofilm Type PME 60	115-2639	1

NOTE: REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

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KEPCO. REPLACEMENT PARTS LIST

PRINTED CIRCUIT BOARD ASSEMBLY (A1), MODEL NTC 2000 **Code 4-1478**

REFERENCE DESIGNATION	QTY.	DESCRIPTION	MFRS. NAME & PART NO. SEE BOTTOM NOTE	KEPCO PART NO.	REC. SPARE PART QTY.
R25,26	2	Resistor, Fixed, Precision, M.F. 1.5K ohm, 1/4W, 1%	Dale Type MFF-1/4	115-1838	1
R27	1	Resistor, Fixed, Molded 22K ohm, 1W, 5%	Allen Bradley GB2235	115-0275	1
R28,29	2	Resistor, Fixed, Precision, M.F. 634 ohm, 1/4W, 1%	Dale Type MFF-1/4	115-1989	1
R30	1	Resistor, Fixed, Molded 220 ohm, 1/2W, 5%	Allen Bradley EB2215	115-0470	1
R31	1	Resistor, Fixed, Molded 10K ohm, 1/4W, 10%	TRW Type GBT-1/4	115-2211	1

NOTE: REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS REPRESENTS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN OBTAINING REPLACEMENT PARTS LOCALLY. WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC

KEPCO® REPLACEMENT PARTS LIST

MAIN CHASSIS ASSEMBLY, MODEL NTC 2000

Code 4-1478

REFERENCE DESIGNATION	QTY.	DESCRIPTION	MFRS. NAME & PART NO. SEE BOTTOM NOTE	KEPCO PART NO.	REC. SPARE PART QTY.
C101	1	Capacitor, Ceramic Disc 22pF, 3KV, 20%	Sprague Type 30GA Q22	117-0891	1
DS101	1	Pilot Light	Industrial Devices Type 1V	152-0089	0
R101,102	2	Resistor, Fixed, Precision 1M ohm, 2W, 1%	Kelvin Associates Type RB-59	115-2186	1
RC101	1	RC Network 0.1uF, 20%, 400V And 100 ohm, 10%, 1/2W	Sprague Type 288P	245-0003	1
S101	1	Switch, SPST	Stackpole RS-47-FB	127-0230	0
C201	1	Capacitor, Can, Dual 0.3uF, 4KV, 10%	General Electric Type 28F	117-0380	0
F201	1	Fuse, Slow Blow 0.6A A-SB	Bussman Type MDL 6/10	141-0077	5
CR201	1	Rectifier, Silicon, Axial Leads	Semicon, Inc. HV-30	124-0137	1
R201	1	Resistor, Fixed, Power, Axial 7.5M, ohm, 5%, 2W	TRW MVX-2	115-1317	1

H.V. RECTIFIER ASSEMBLY (A3) CONTAINS:

C301	1	Capacitor, Ceramic Disc 0.002uF, 5KV, 20%	Centralab DD-60-202	117-0310	1
CR301,302, 303,304	4	Rectifier, Silicon, Axial Leads 4KV (PIV), 50mA	Semicon, Inc. HV-40	124-0163	3
R301	1	Resistor, Fixed, Molded 100K ohm, 1W, 10%	Allen Bradley GB1041	115-0035	1
R302,303,304, 305,306	5	Resistor, Fixed, Power, Axial 50K ohm, 20W, 5%	Ward Leonard 20S50000	115-1010	1

NOTE REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION

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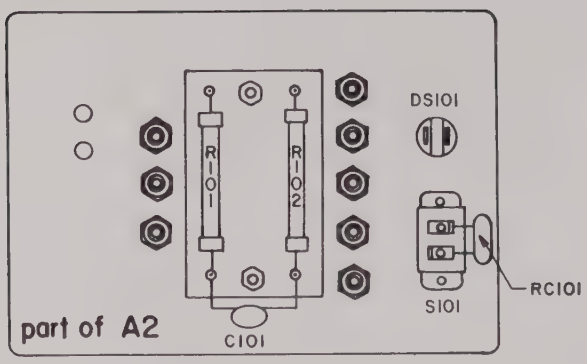


(FRONT PANEL REAR VIEW)

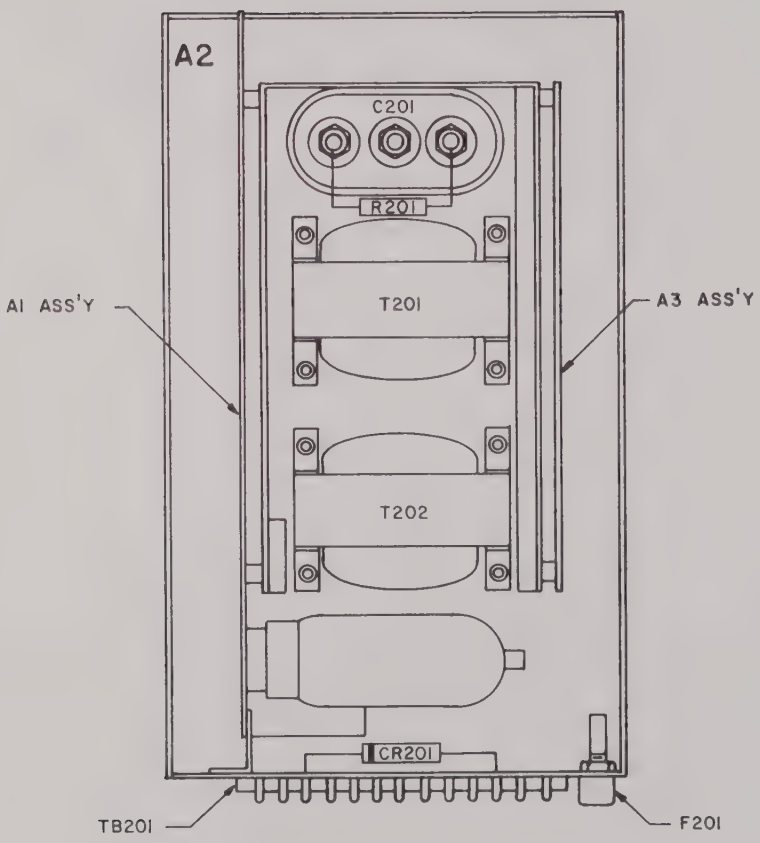
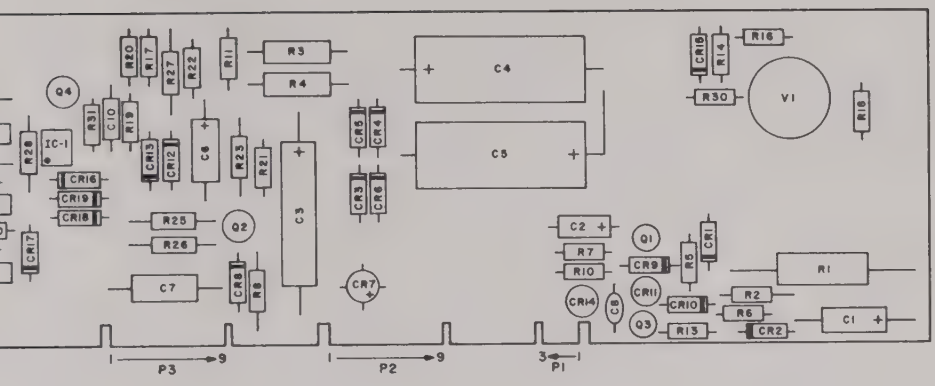


FIG. 6-1 COMPONENT LOCATION, MAIN CHASSIS.



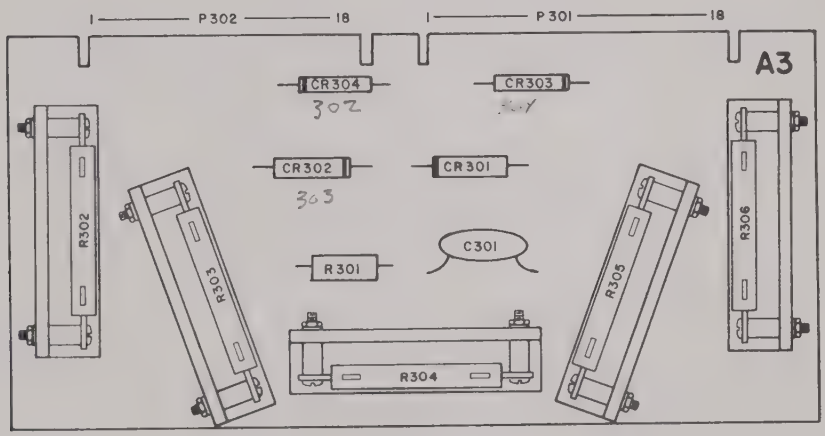
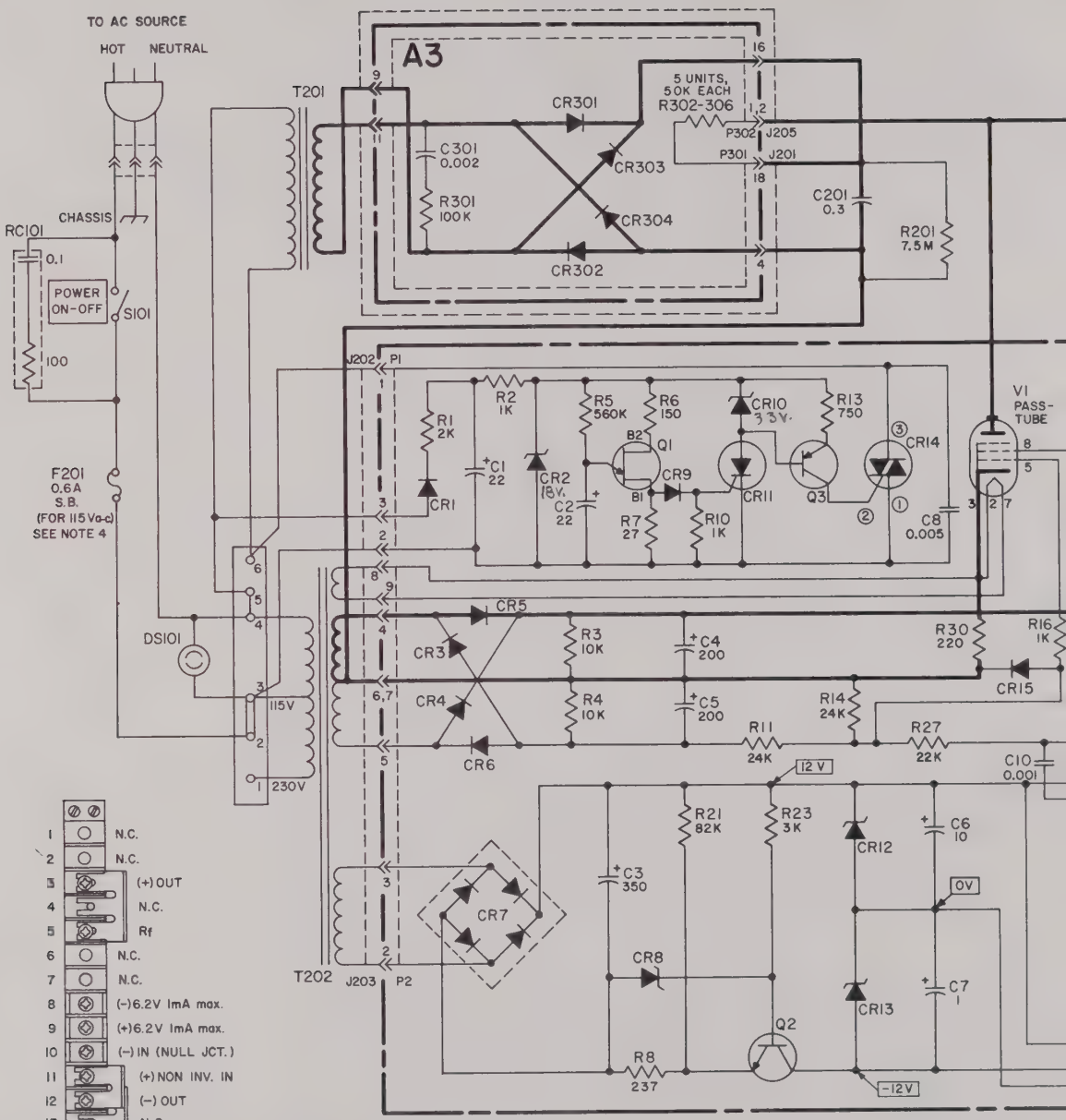
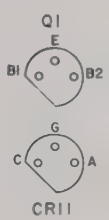


FIG. 6-2 COMPONENT LOCATION, PCB (A1) AND (A3) ASSEMBLIES.



NOTES:

1. RESISTOR VALUES IN OHMS, K=1000.
2. CAPACITOR VALUES IN MICROFARADS, UNLESS INDICATED OTHERWISE.
3. VOLTAGE READINGS TAKEN UNDER THE FOLLOWING CONDITIONS:
   A) METER 20K OHMS / VOLT.
   B) READINGS WITH REFERENCE TO "COMMON" UNLESS INDICATED OTHERWISE.
   C) I_o=0, E_o= MAX RATED, PRODUCED BY CONNECTING A 6.2K OHM, 0.5 W, W.W. RESISTOR FROM (-)6.2 V TO NULL, (TERMINALS 10, 8 ON TB201).
   D) READINGS SUBJECT TO NORMAL COMPONENT TOLERANCES.
4. FUSE VALUE FOR 230 Vac SOURCE: 0.3A – S.B.



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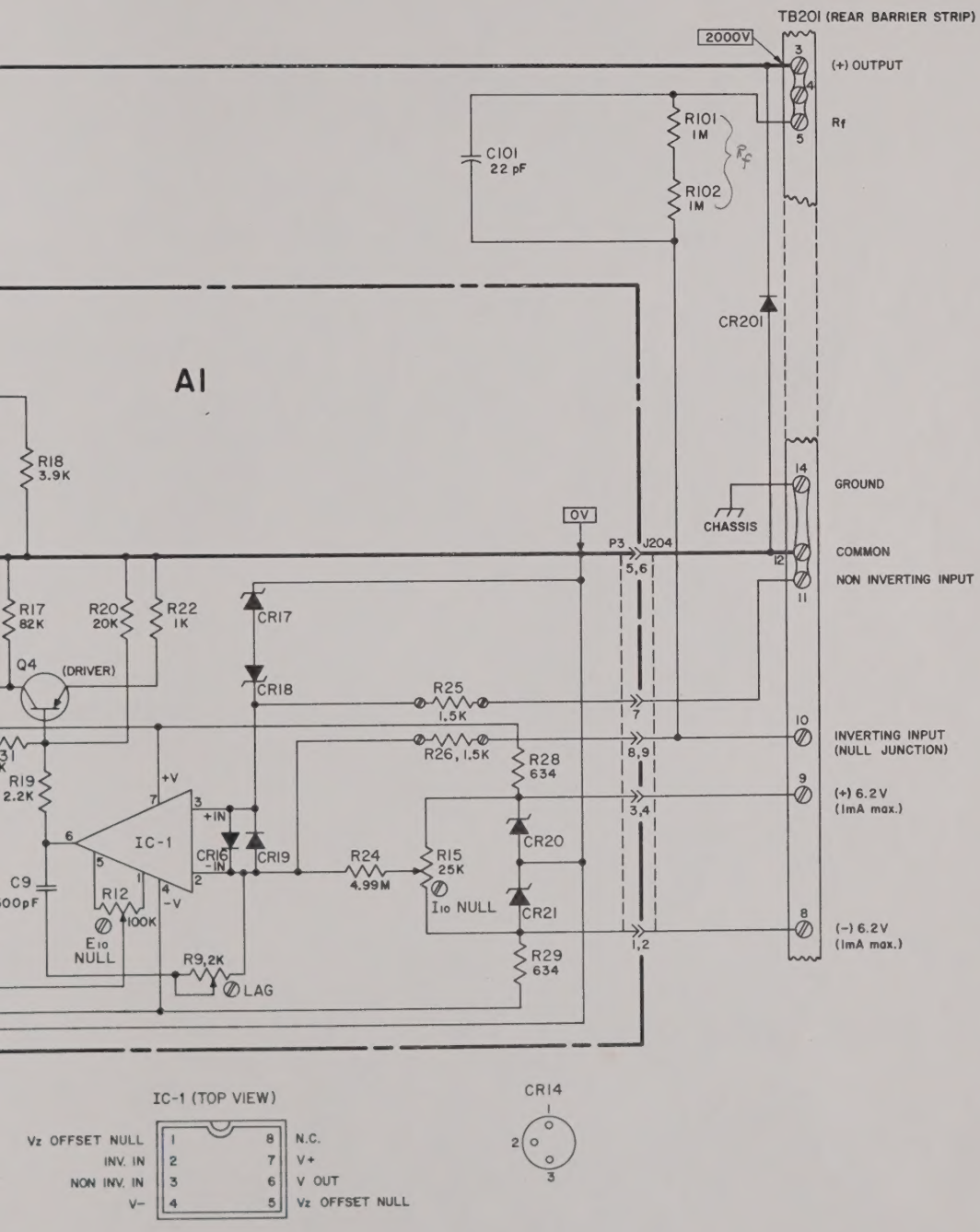

FIG. 6-3 MAIN SCHEMATIC, MODEL NTC 2000.

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